PROJECT MANAGEMENT & SYSTEMS ENGINEERING-A

Integrated Project Management

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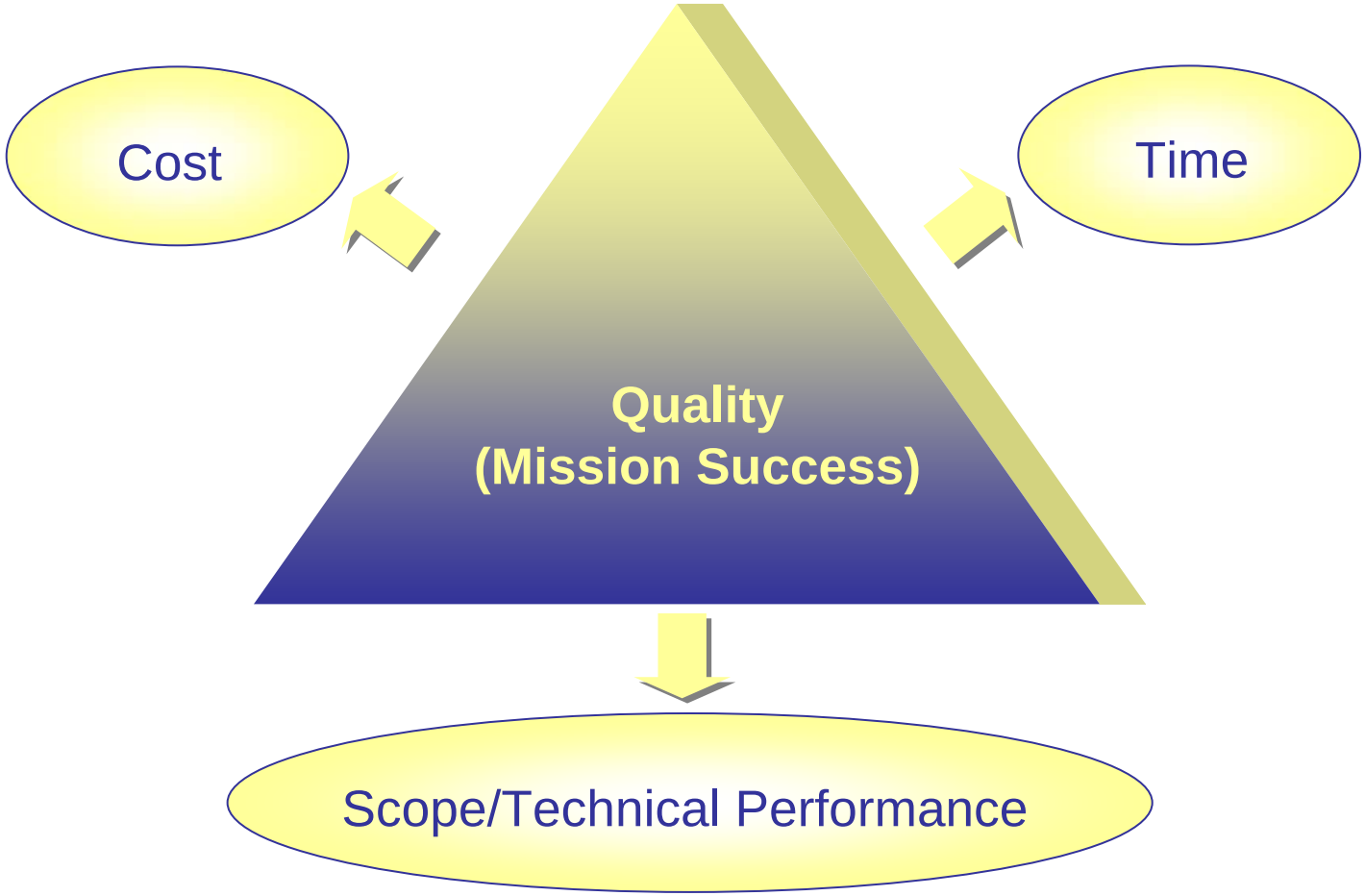
PM Challenge 2007 Video

The Big Dig

The Project Triple Constraint



Project Success

"The true measure of project success is the point when your project is completed and when the true project results can be measured"

- Jeff Berman, "Maximizing Project Value," 2007

Learning Objectives

- Upon completion of the course, participants will be able to:
  - Understand the importance of cost and schedule management to mission success
  - Plan and manage within the realities of the Federal budget environment
  - Understand basic planning techniques and schedule communication tools
  - Develop skills for successful budget justification through range estimating
  - Understand how cost and schedule can be effectively integrated through earned value management
  - Communicate project performance status with vendors and management
  - Forecast the project estimate at completion based on performance data

Things We Need to Know

What is a project?

How does NASA get money to operate?

What's a WBS and why do I need one?

How long will it take to finish my project?

What is a critical path?

How does the budget relate to my schedule?

How much will my project cost?

What is a baseline?

What is earned value management?

Why do we have to measure performance and how do we do it?

How can I use EVM to forecast my project's future performance?

How do I close out a project?

Contents

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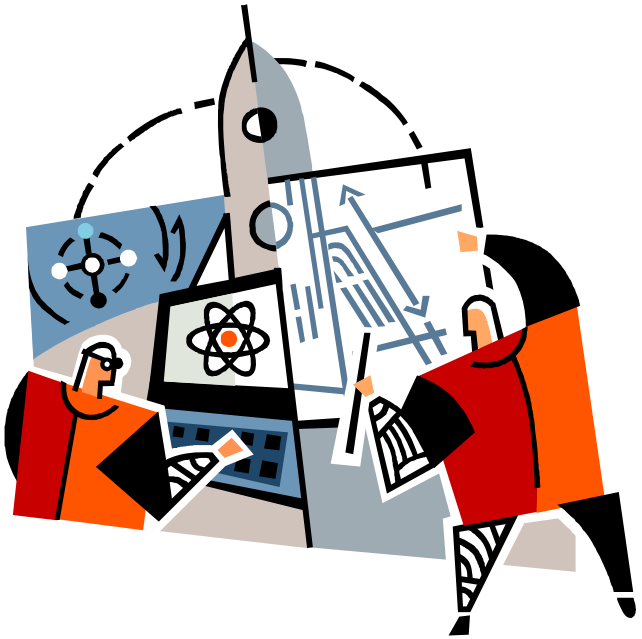
Integrated Project Management Overview



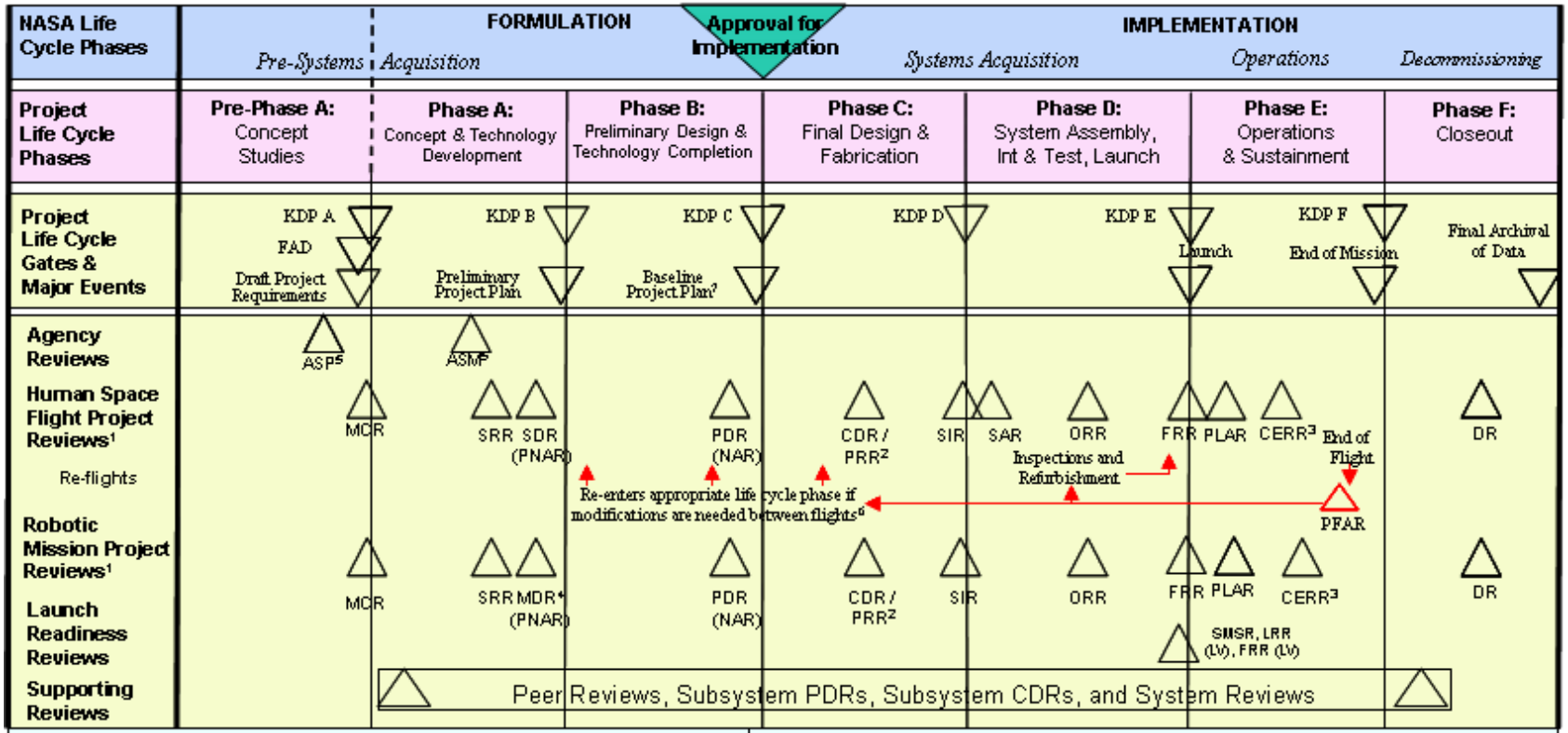
What is a project?

A Project According to 7120.5D

- Specific investment with a beginning and end
- Defined requirements and a life cycle cost
- Yields new or revised products that directly address NASA's strategic needs
- Moves through phases which are called
  - Concept Studies (Pre-Phase A)
  - Concept & Technology Development (Phase A)
  - Preliminary Design & Technology Completion (Phase B)
  - Final Design and Fabrication (Phase C)
  - System Assembly, Integration and Test, and Launch (Phase D)
  - Operations and Sustainment (Phase E)
  - Closeout (Phase F)

Source: NPR 7120.5D

The NASA Project Life Cycle



FOOTNOTES

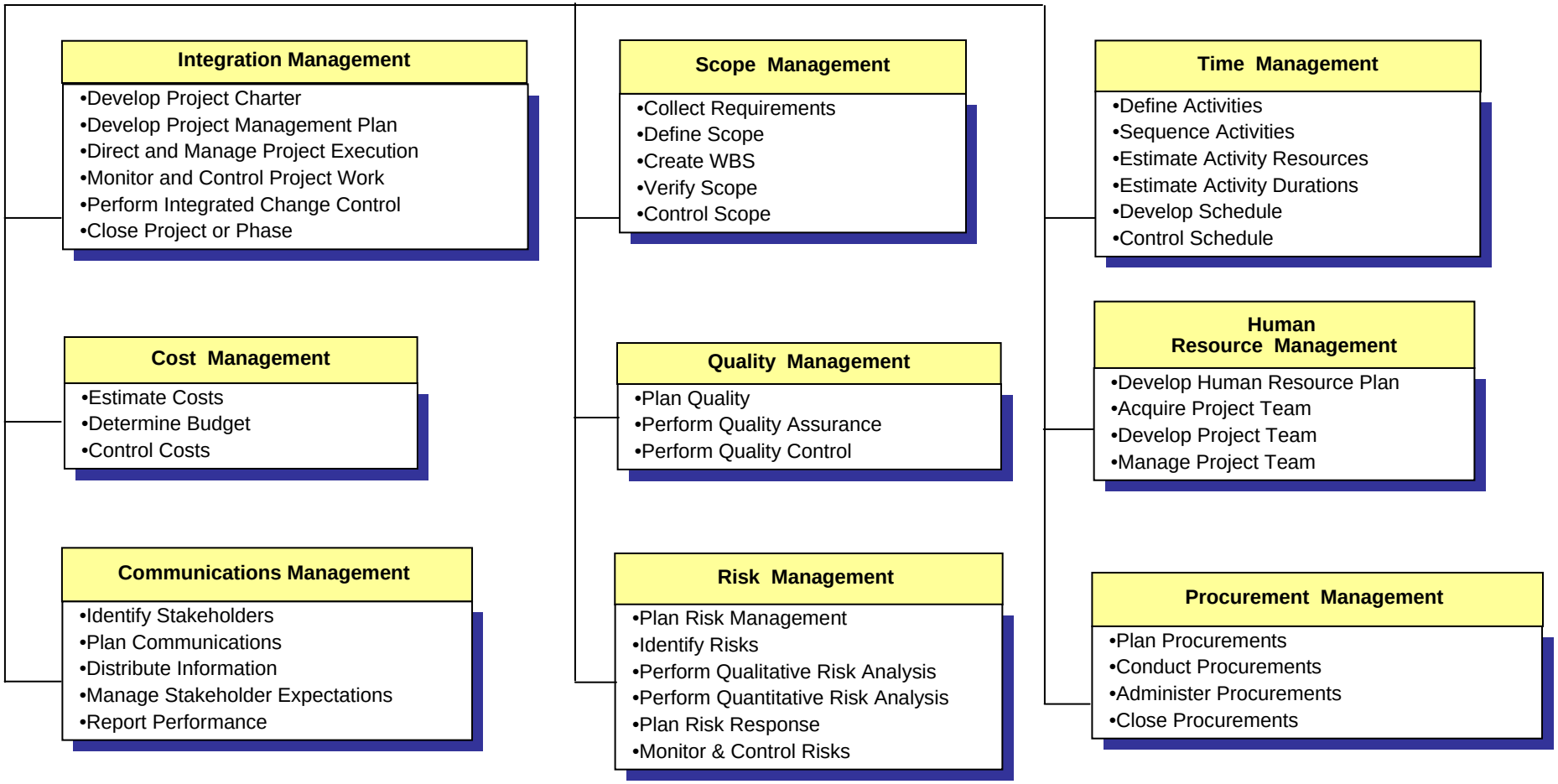
1. Flexibility is allowed in the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan. These reviews are conducted by the project for the independent SRB. See Section 2.5 and Table 2-6.
2. PRR needed for multiple (≥4) system copies. Timing is notional.
3. CERRs are established at the discretion of Program Offices.
4. For robotic missions, the SRR and the MDR may be combined.
5. The ASP and ASM are Agency reviews, not life-cycle reviews.
6. Includes recertification, as required.
7. Project Plans are baselined at KDP C and are reviewed and updated as required, to ensure project content, cost, and budget remain consistent.

ACRONYMS

ASP—Acquisition Strategy Planning Meeting
ASM—Acquisition Strategy Meeting
CDR—Critical Design Review
CERR—Critical Events Readiness Review
DR—Decommissioning Review
FAD—Formulation Authorization Document
FRR—Flight Readiness Review
KDP—Key Decision Point
LRR—Launch Readiness Review
MCR—Mission Concept Review
MDR—Mission Definition Review
NAR—Non-Advocate Review
ORR—Operational Readiness Review
PDR—Preliminary Design Review
PFAR—Post-Flight Assessment Review
PLAR—Post-Launch Assessment Review
PNAR—Preliminary Non-Advocate Review
PRR—Production Readiness Review
SAR—System Acceptance Review
SDR—System Definition Review
SIR—System Integration Review
SMSR—Safety and Mission Success Review
SRR—System Requirements Review

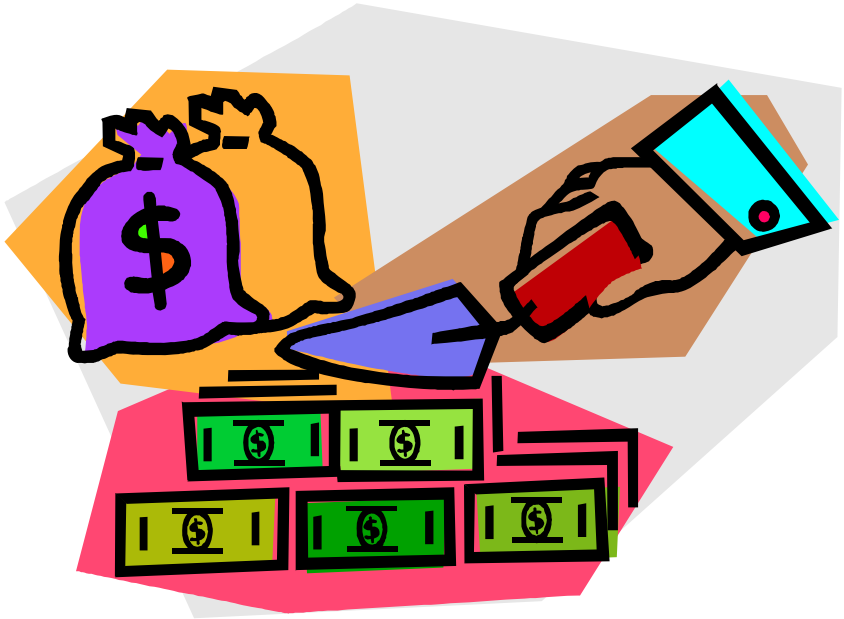
SOURCE: NPR 7120.5D

Integrated Project Management



SOURCE: A Guide to the Project Management Body of Knowledge (PMBOK® Guide) Fourth Edition

The NASA Budget Process

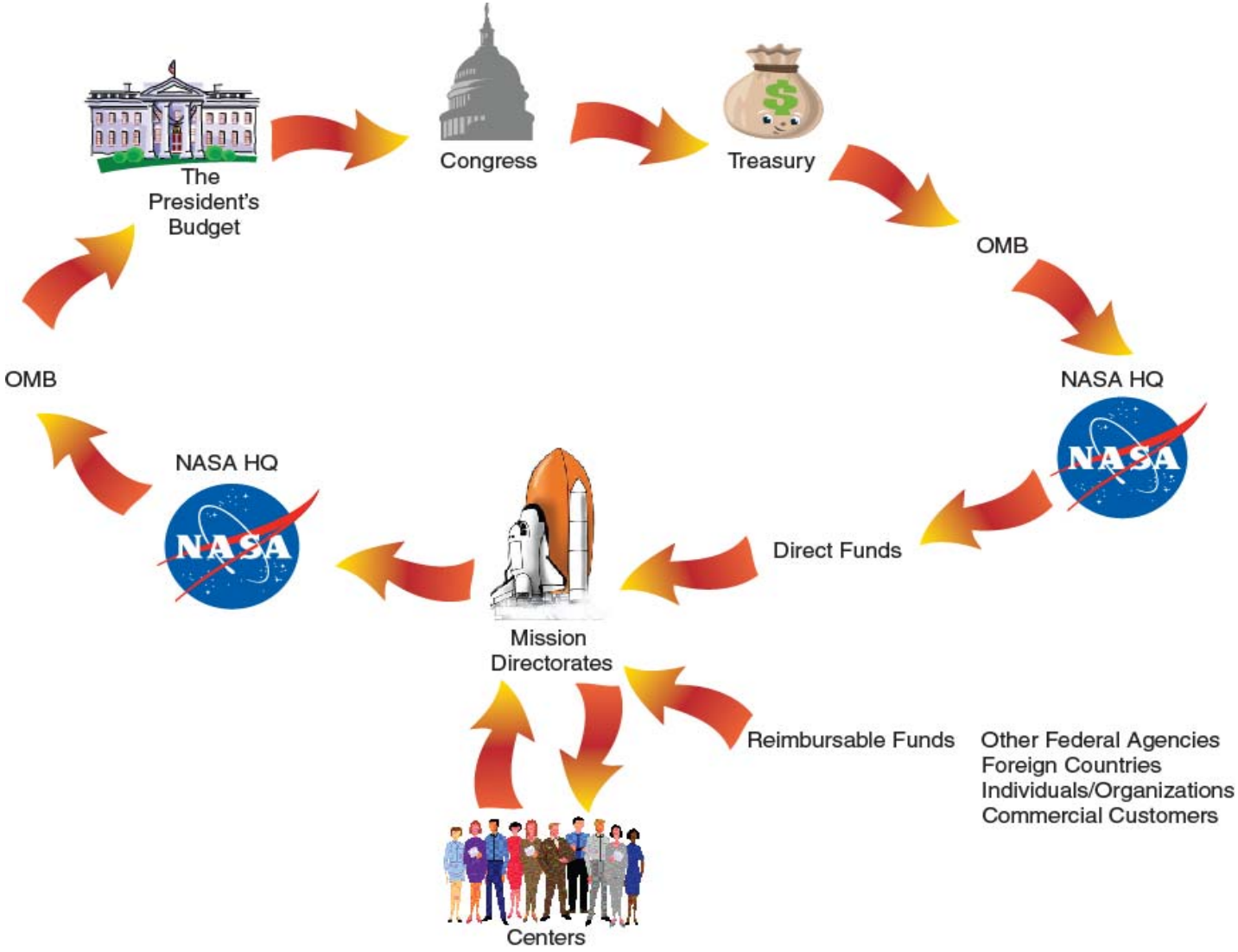


How does NASA get money to operate?

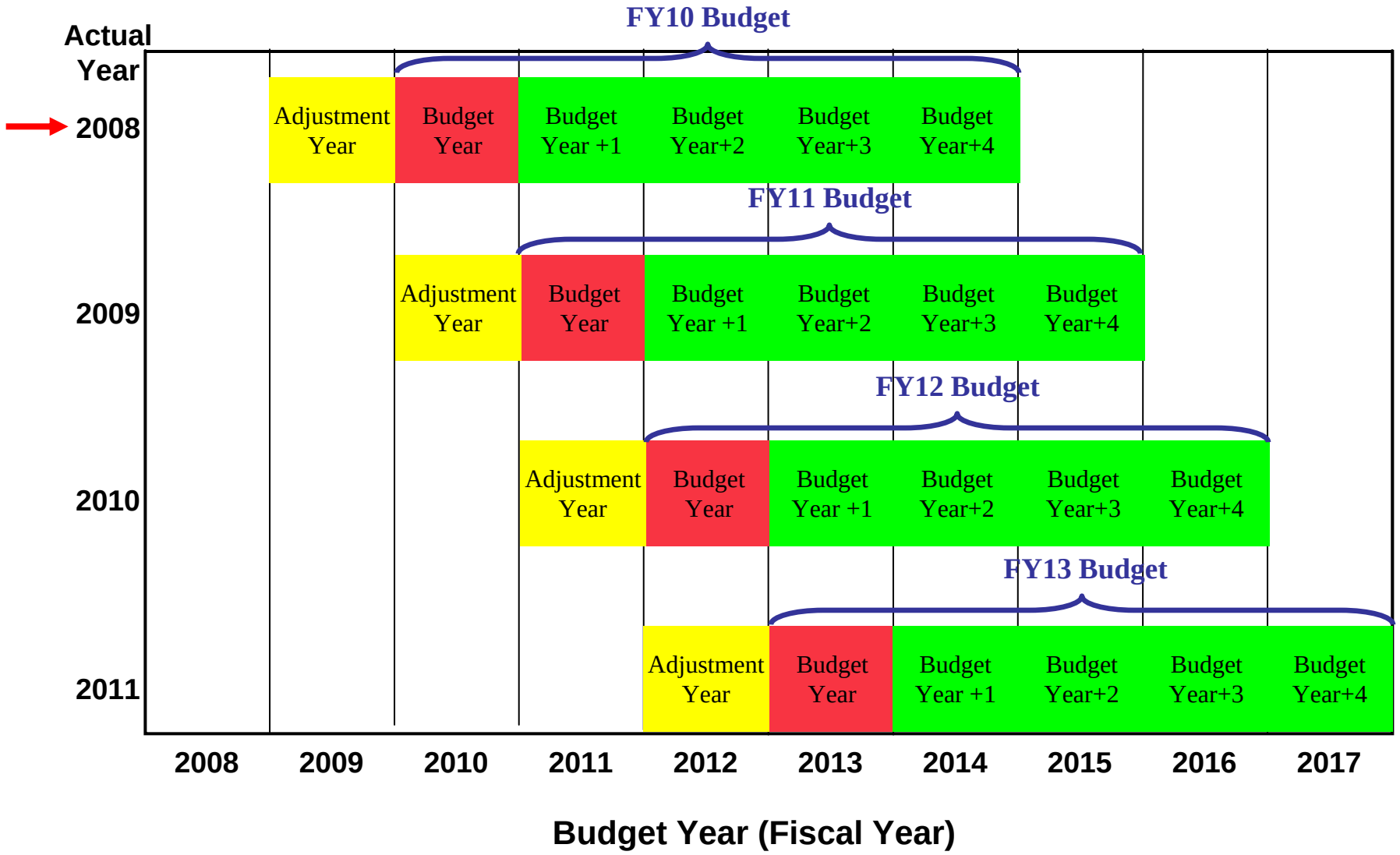
A Budget is…

- A *political instrument* that allocates scarce public resources among the social & economic needs of the jurisdiction
- A *managerial/administrative instrument* that ensures all programs/activities will be reviewed at least once a year
- An *economic instrument* that can direct the nation's economic growth & development
- An *accounting instrument* that holds government officials responsible for the funds with which they have been entrusted
- A *fiscal plan* of operations for the project

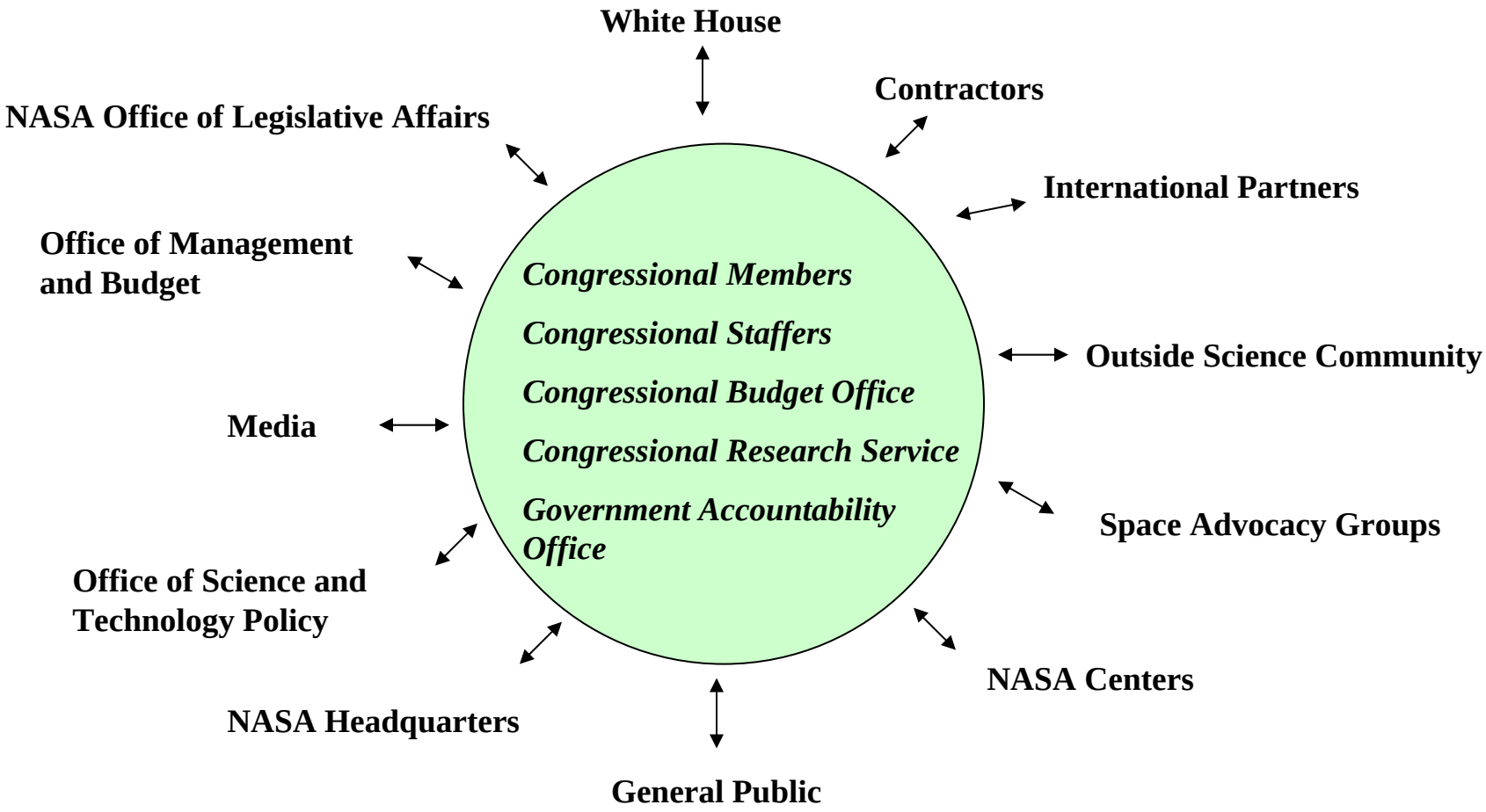
The Budget Continuum



The Budget Horizon



Who Influences the NASA/Congress Relationship



What is the bottom line? Our system is perfectly designed to not be efficient.
To protect freedom and liberty is it's purpose. No one player holds the key to power.

Why Is Good Budget Development Important?

- NASA's budget receives a great deal of scrutiny from Congress, the Executive Branch, and the public
- Agency has been asked to do more
  - Have to justify every dollar spent
  - Need to know how much is needed and why
  - Requires efforts of technical, resources, and management personnel
  - More emphasis meeting our agreements with respect to cost and schedule

How Important are Cost and Schedule?

- "NASA plans to spend nearly $230 billion alone, over the next two decades, to implement the President's 2004 Vision for Space Exploration. Implementing the Vision, including establishing a permanent lunar outpost, will entail a multitude of contracts and will require a sustained commitment from multiple administrations and Congresses over the length of the program. The realistic identification of needed resources and accurate accounting of cost and contractor performance would go a long way to provide support for such a sustained commitment and provide the basis for congressional oversight."

  - Highlights of GAO-07-310, a report to Congress on GAO's High-Risk Series, January 2007

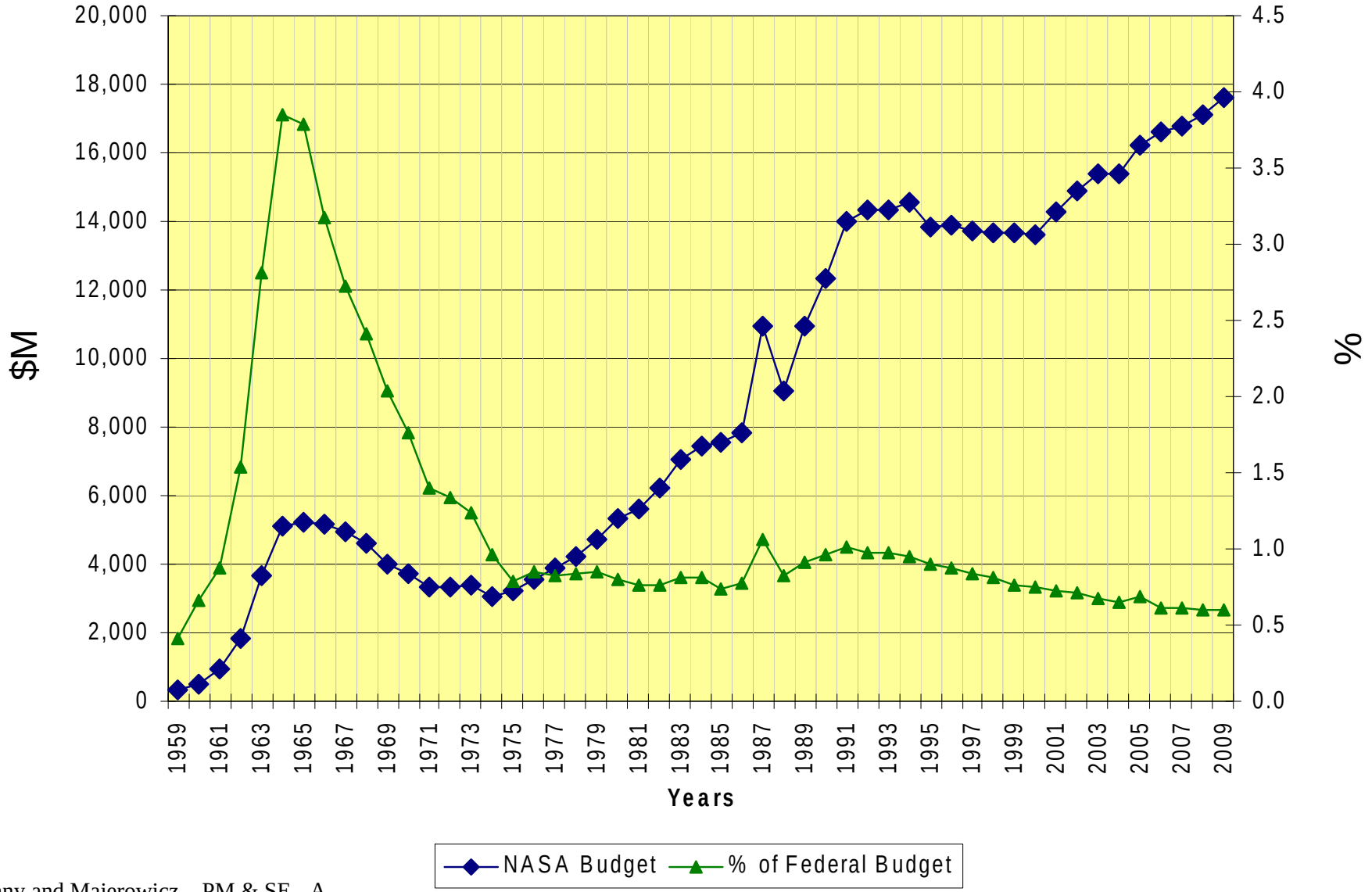
America's Fiscal Condition and Outlook (Video)

David M. Walker
(Former) Comptroller General of the United States

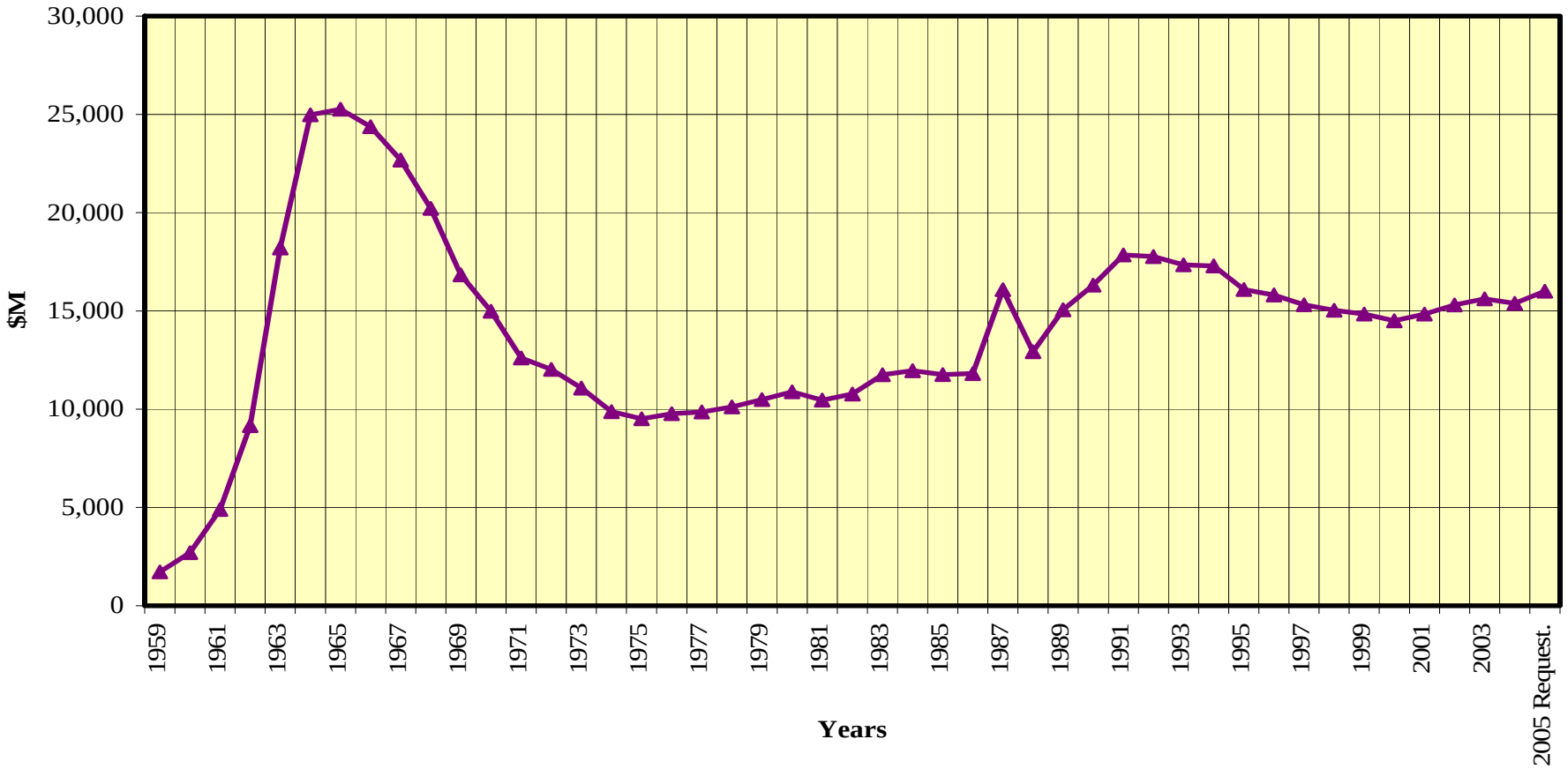
FY2005 NASA Authorization Bill

- Definitions
  - Development cost is from PDR to IOC (Phase C/D)
  - Life Cycle Cost is from PDR through end of Phase E
- Major program is one with a life cycle cost of > $250M
- Congressional notification triggers
  - Development cost growth of 15% or…
  - 6 month slip in any major milestone
- Notification entails…
  - Magnitude of expected growth
  - Reasons for growth
  - Impacts to other programs/projects [siblings]
  - The revised cost and schedule if initial project requirements are held
  - The revised cost and schedule if remedial actions are taken [e.g. de-scopes]
  - An Analysis of Alternatives (AOA) with revised cost and schedule estimates
- Project termination required at 30% cost growth unless Congress authorizes continuation by law

NASA Budget as a Percent of Federal Budget



NASA Historical Funding (Constant 2004$)



President's FY2009 Budget Request

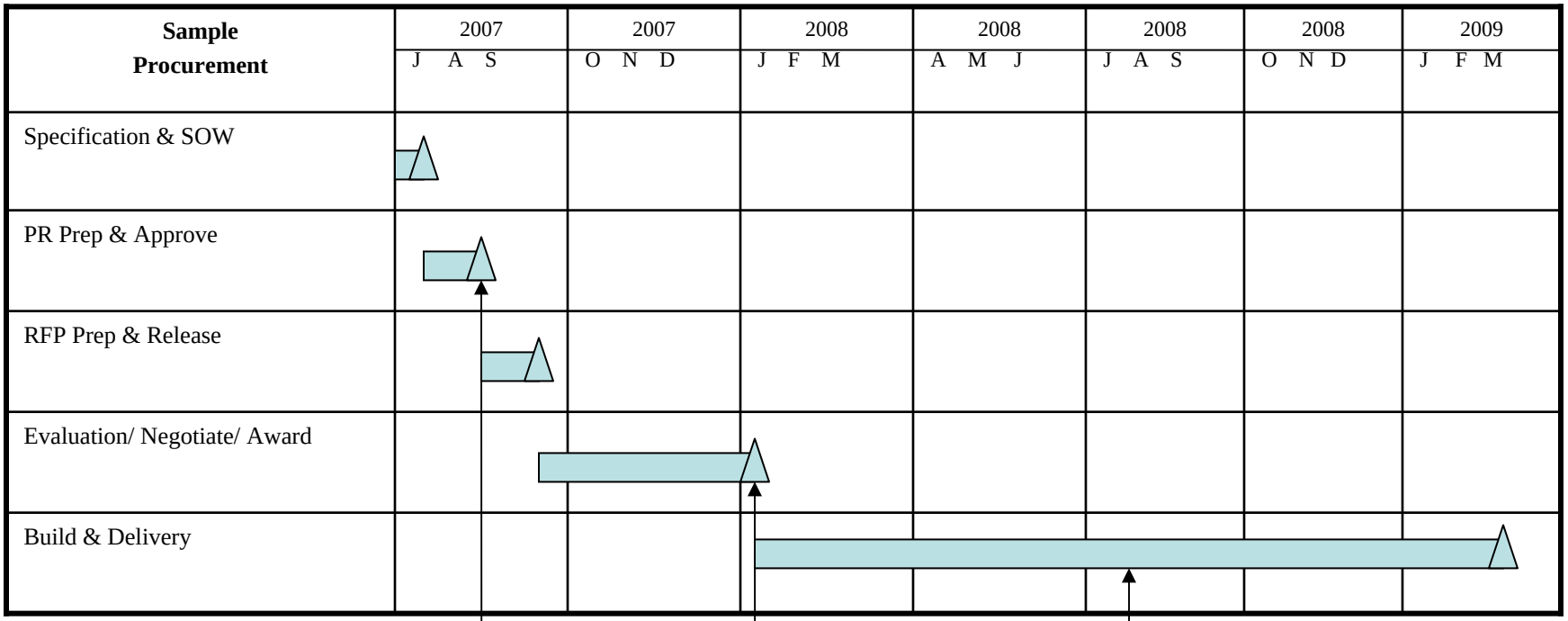
Budget Authority, $ in millions By Appropriation Account By Theme	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Science	**4,609.9**	**4,706.2**	**4,441.5**	**4,482.0**	**4,534.9**	**4,643.4**	**4,761.6**
Earth Science	1,198.5	1,280.3	1,367.5	1,350.7	1,250.9	1,264.4	1,290.3
Planetary Science	1,215.6	1,247.5	1,334.2	1,410.1	1,537.5	1,570.0	1,608.7
Astrophysics	1,365.0	1,337.5	1,162.5	1,122.4	1,057.1	1,067.7	1,116.0
Heliophysics	830.8	840.9	577.3*	598.9	689.4	741.2	746.6
Aeronautics	**593.8**	**511.7**	**446.5**	**447.5**	**452.4**	**456.7**	**467.7**
Exploration	**2,869.8**	**3,143.1**	**3,500.5**	**3,737.7**	**7,048.2**	**7,116.8**	**7,666.8**
Constellation Systems	2,114.7	2,471.9	3,048.2	3,252.8	6,479.5	6,521.4	7,080.5
Advanced Capabilities	755.1	671.1	452.3	484.9	568.7	595.5	586.3
Space Operations	**5,113.5**	**5,526.2**	**5,774.7**	**5,872.8**	**2,900.1**	**3,089.9**	**2,788.5**
Space Shuttle	3,315.3	3,266.7	2,981.7	2,983.7	95.7	-	-
International Space Station	1,469.0	1,813.2	2,060.2	2,277.0	2,176.4	2,448.2	2,143.1
Space and Flight Support	329.2	446.3	732.8*	612.1	628.0	641.7	645.4
Education	**115.9**	**146.8**	**115.6**	**126.1**	**123.8**	**123.8**	**123.8**
Cross-Agency Support	**2,949.9**	**3,242.9**	**3,299.9**	**3,323.9**	**3,363.7**	**3,436.1**	**3,511.3**
Center Management and Operations	1,754.9	2,013.0	2,045.6	2,046.7	2,088.0	2,155.3	2,211.6
Agency Management and Operations	971.2	830.2	945.6	945.5	939.8	950.5	961.3
Institutional Investments	223.8	319.7	308.7	331.7	335.9	330.4	338.3
Congressionally Directed Items	-	80.0	-	-	-	-	-
Inspector General	**32.2**	**32.6**	**35.5**	**36.4**	**37.3**	**38.3**	**39.2**
FY 2008 Rescission**		(192.5)					
NASA FY 2009	16,285.0	17,309.4	17,614.2	18,026.3	18,460.4	18,905.0	19,358.8
Year to Year Change		6.3%	1.8%	2.3%	2.4%	2.4%	2.4%

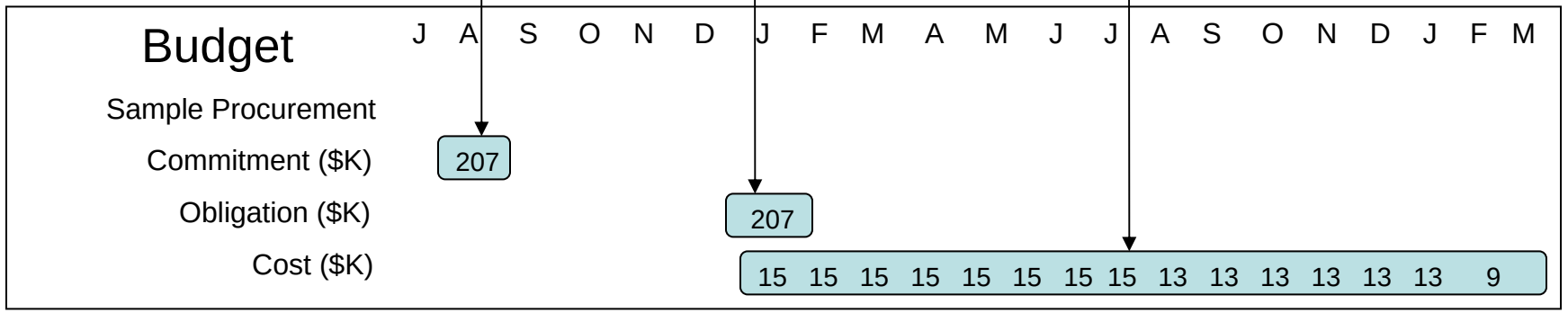
Budgets include all direct costs required to execute the programs. Indirect costs are now budgeted within Cross-Agency Support.
* Deep Space and Near Earth Networks transfers $256 million to Space and Flight Support in FY 2009.
** FY 2008 Appropriation rescinded $192.475M in prior-year unobligated balances, effectively reducing FY 2008 authority. Not included in totals.
FY 2008 Budgets are the enacted levels per the Agency's FY 2009 Budget Estimates. Totals may not add due to rounding.

Antideficiency Act, Section 1341 of Title 31, US. Code

- Prohibits a Federal employee from:
  - Obligating, expending or authorizing the use of funds exceeding the amount available in an appropriation or fund
  - Involving the Federal Government in any contract or obligation for payment of money before an appropriation is made available
- If an employee violates the Antideficiency Act:
  - Discipline includes written reprimand, suspension of employment duty without pay, or removal from office
  - In addition, conviction of willfully and knowingly violating the act can result in a fine not more than $5000, imprisonment for not more than 2 years, or both

Cost / Schedule Integration

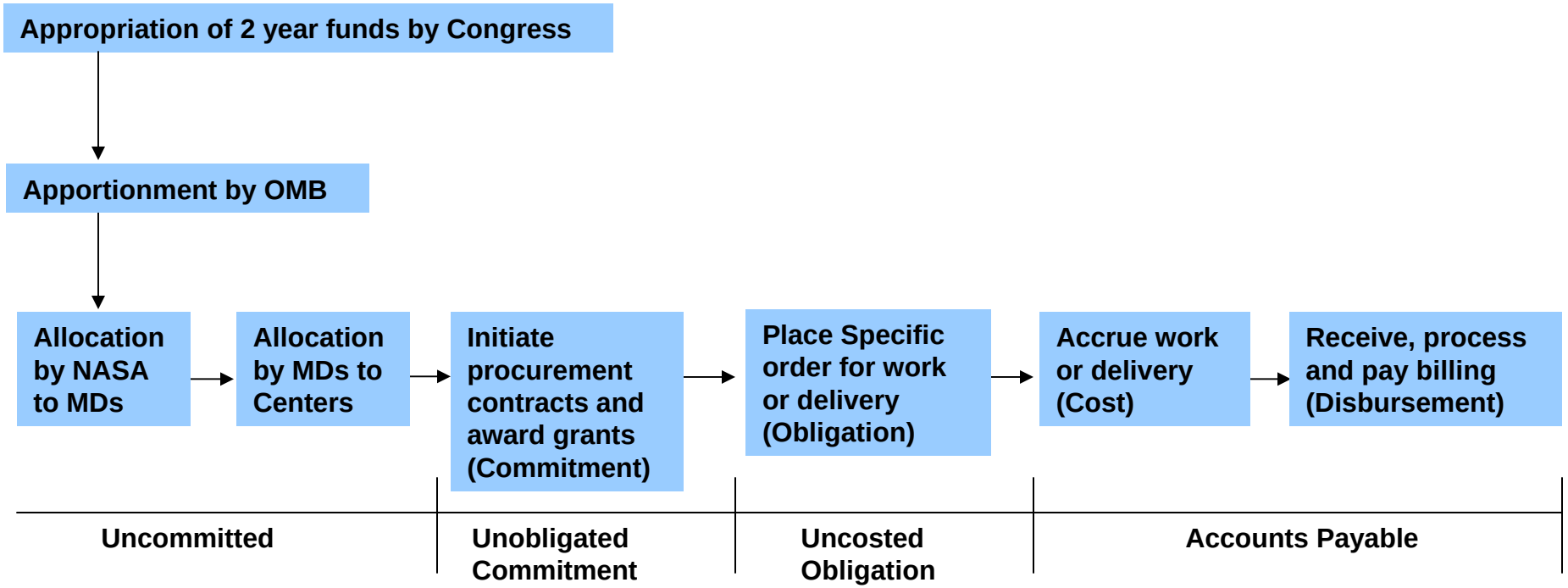




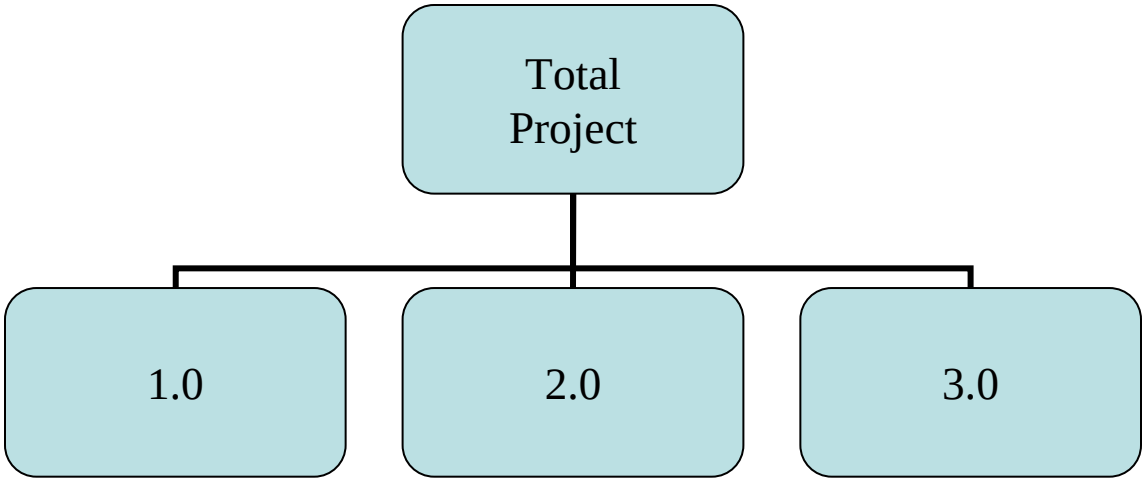
Commitments, Obligations and Cost

- Commitment
  - Funds that have been set aside based on approved requisitions, procurement requests, authorization to execute contracts, or other written evidence which authorizes the creation of obligations
- Obligation
  - Represent and are supported by a legally binding agreement that will result in the expenditure of funds immediately or in the future
- Cost
  - The monetary value of resources used or sacrificed to achieve an objective, such as to acquire or produce a good or to perform an activity or service

The Lifecycle of an Appropriation



Defining the Project Scope: The WBS



What's a WBS and why do I need one?

Defining the Project Scope

- Project scope
  - All of the work required, and only the work required, to successfully complete the project
- To define the job, we must understand:
  - What constitutes 100% of the entire job
    - Otherwise, we can't tell what percentage of the work is complete or what amount is yet to be accomplished
  - When the project is supposed to start and finish
  - The difference between the agreed to work and new work requests (changes)

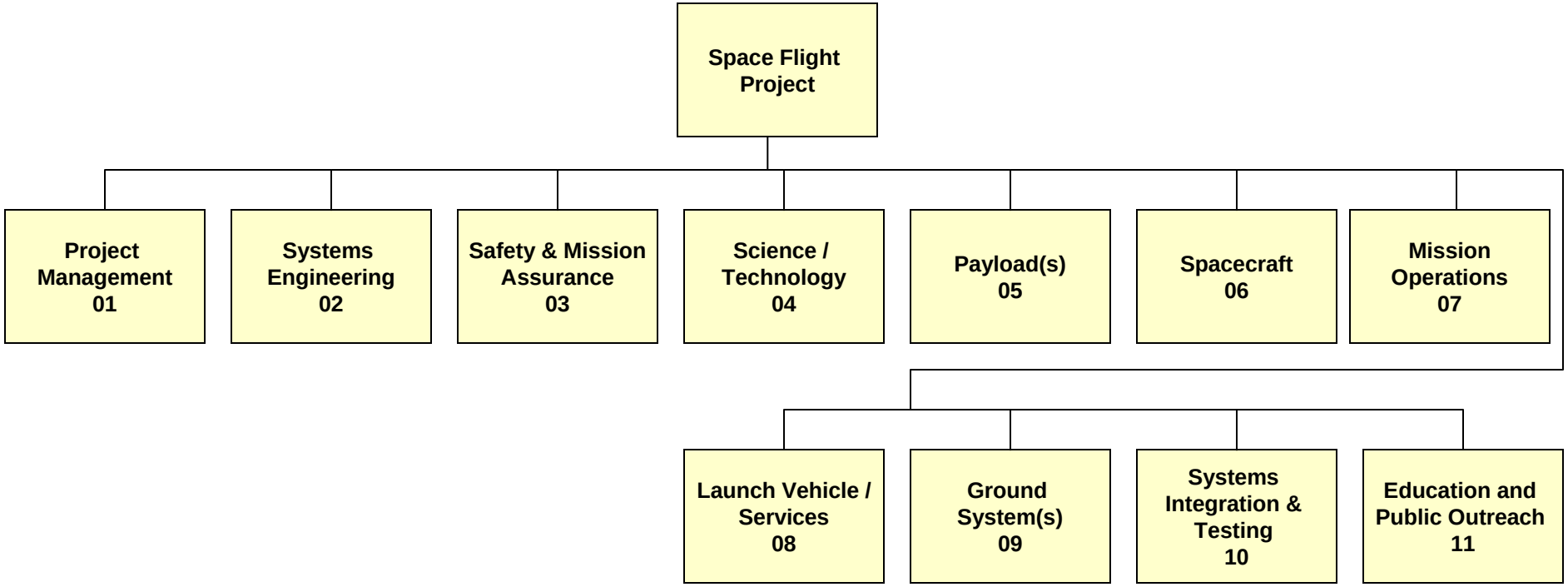
Project Scope Documentation

- Project scope documentation describes the project's deliverables and the work required to accomplish them. It may include:
  - Project objectives
  - Product scope description
  - Project requirements
  - Project deliverables
  - Project constraints and assumptions
  - Initial project organization
  - Initial risk listing
  - Customer or sponsor-imposed milestones
  - Initial cost estimate
  - Configuration and Change Management requirements
  - Specifications (to which the project must comply)

Work Breakdown Structure

- A deliverable-oriented grouping of project elements that organizes and defines the total scope of the project
  - Work not in the WBS is outside of the scope of the project
  - Provides a common understanding of project scope
  - Descending levels represent increasingly detailed descriptions of project scope
    - Identifies discrete tasks that can be individually managed
    - Helps ensure nothing is left out
    - More detail for riskier scope
- Breaks the work scope into appropriate elements for scheduling, estimating, work authorization and cost accounting
- Structured in the way the work will be performed and reflects the way costs will be summarized and reported
- Supports historical cost collection for future estimating purposes
- On cost-reimbursable-type contracts, NASA defines the WBS levels for performance reporting

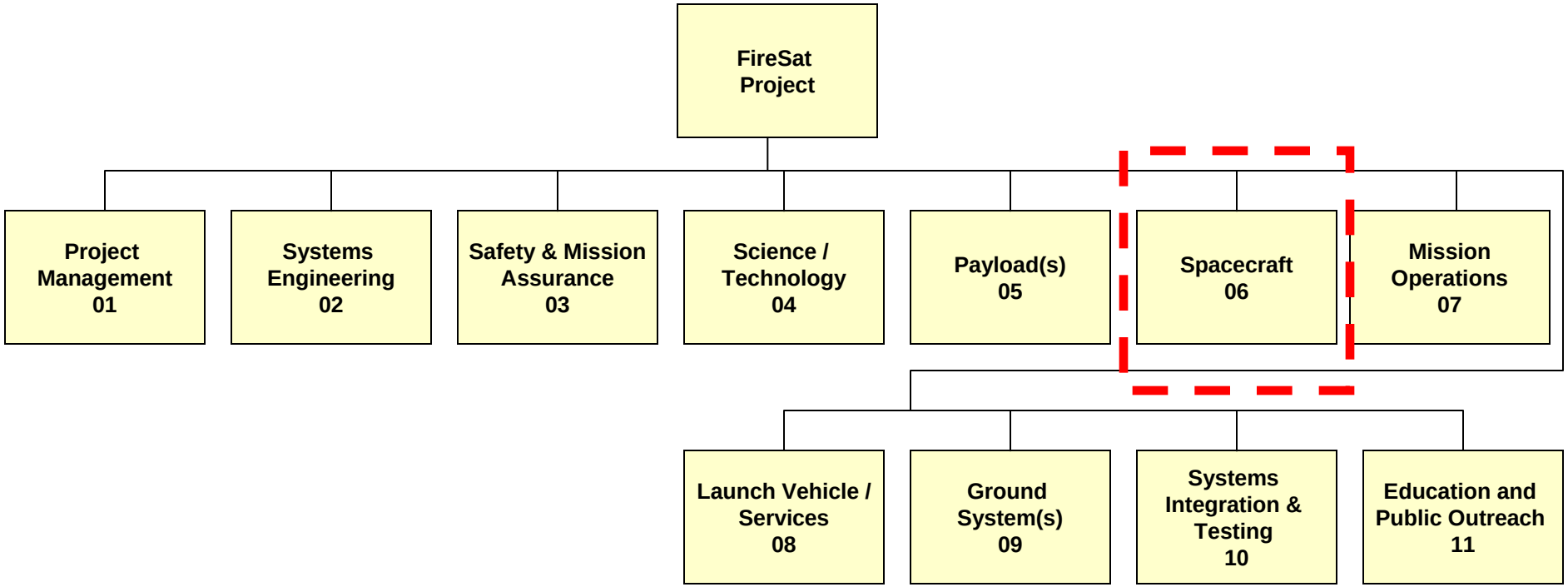
NASA Flight Systems and Ground Support Project WBS Standard Elements



Standard Level 2 WBS elements for space flight projects are shown above. The standard WBS template assumes a typical spacecraft flight development project with relatively minor ground or mission operations elements. For major launch or mission operations ground development activities which are viewed as projects unto themselves, the WBS may be modified. For example, the spacecraft element may be changed to reflect the ground project major deliverable product (such as a facility). The elements such as payload, launch vehicle/services, ground system(s), and mission operations (system) that are not applicable may be deleted.

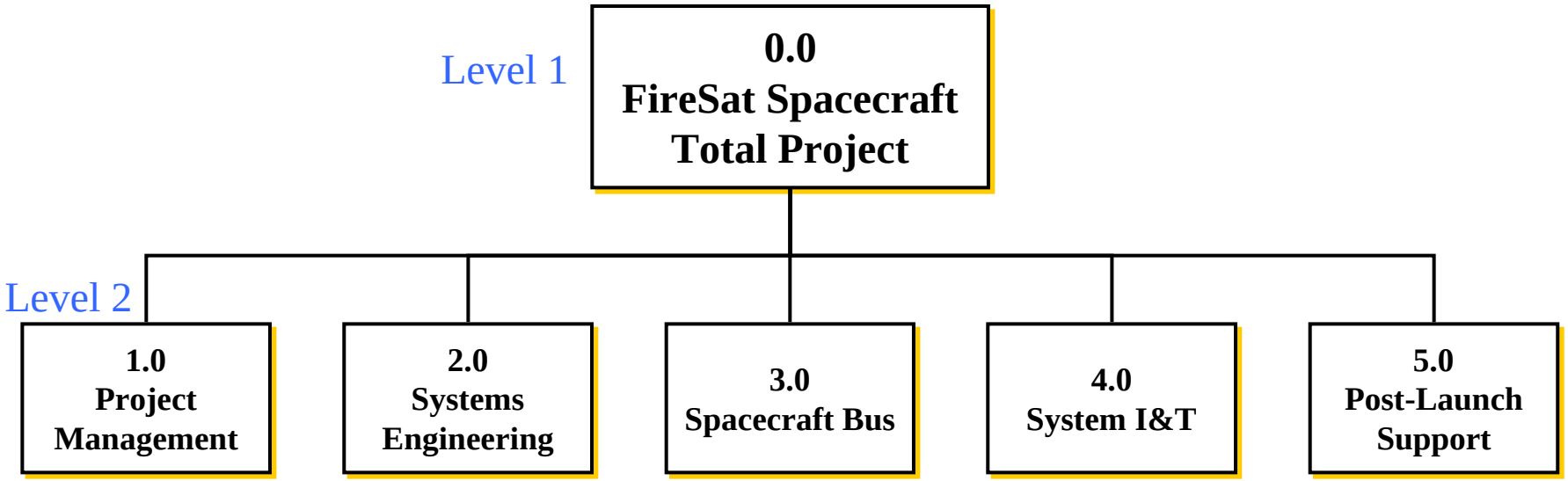
Source: NPR 7120.5D NASA Program and Project Management Processes and Requirements

NASA FireSat Project WBS



- NASA has awarded Acme Space Company (ASC) a $140M cost-plus award fee contract for the FireSat spacecraft
- ASC's scope of work also includes
  - Integrating the GFE payload with the Spacecraft Bus
  - Observatory testing
  - Launch site operations
  - Post launch support

FireSat Spacecraft Bus
Contract Work Breakdown Structure



Level 3
(Partial)

- 3.1 Structures
- 3.2 Power
- 3.3 ADCS
- 3.4 Thermal
- 3.5 Communications
- 3.6 Propulsion
- 3.7 Spacecraft I&T

WBS Dictionary Example

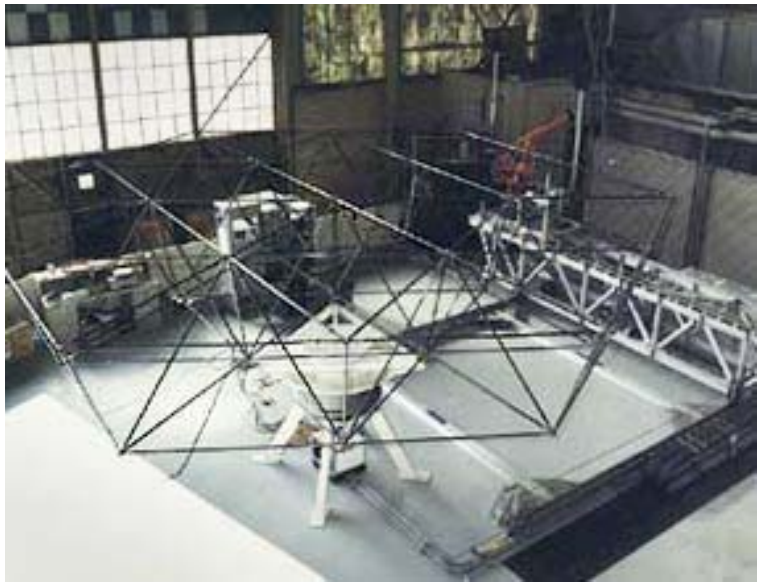
WBS Dictionary

Contract Work Breakdown Structure Dictionary	Program	RFP No.: 5-16372/433	Date: July 2006
	FireSat	Contract No.: NAS5-32314	

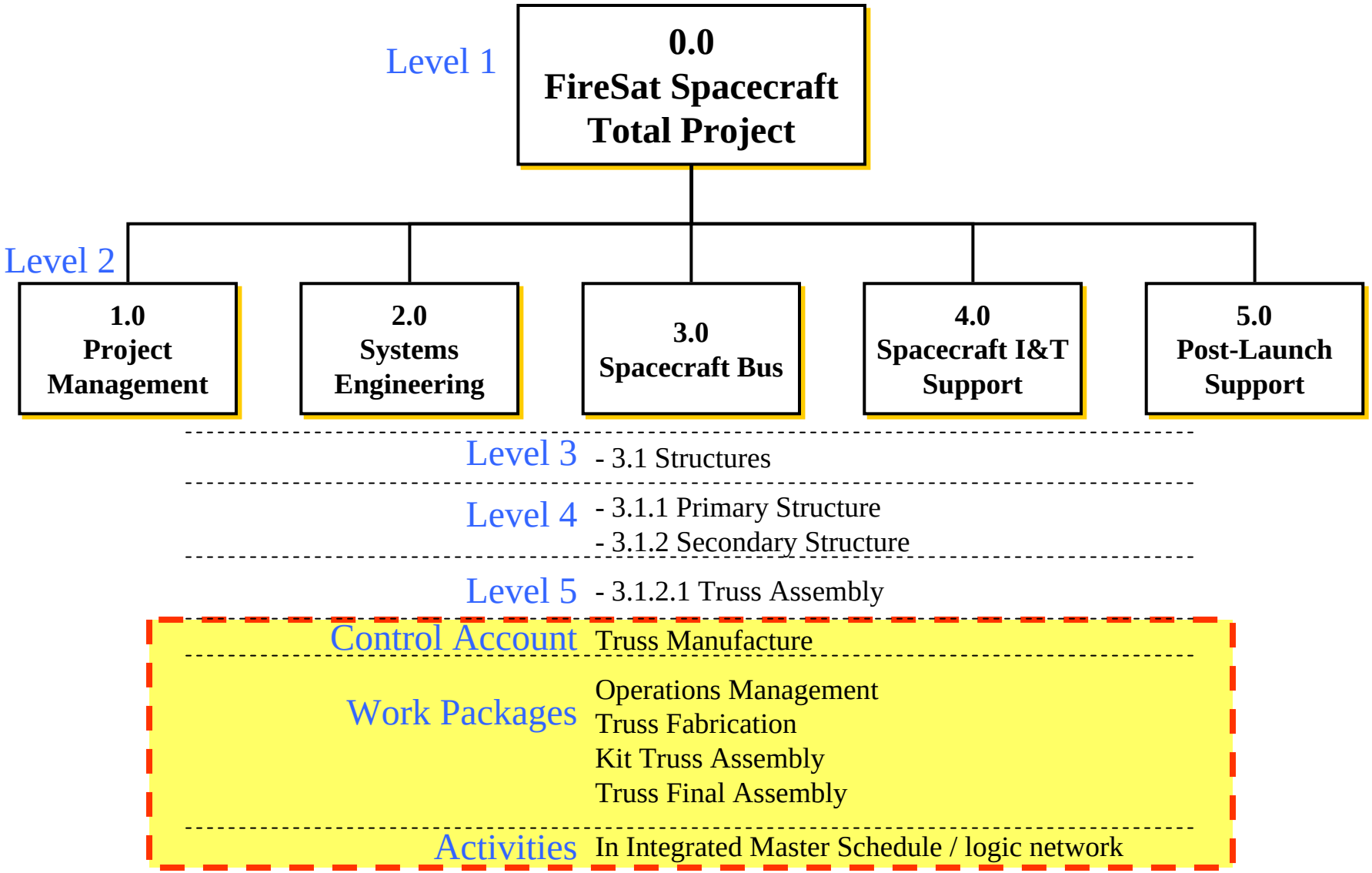
Level of CWBS	CWBS Element	CWBS Definition
4	3.2.2	POWER ELECTRONICS – CONSOLIDATED FAB The fabrication and assembly of electronic components and assemblies including assembly labor, bargaining unit supervision, inspection labor, manufacturing engineering support, shop order preparation, production control support, design engineering support, test engineering support, and test technician support for the consolidated fabrication, assembly and test of sufficient hardware to deliver the following quantities of electronic hardware: 1) 301 Circuit card assemblies of 23 part numbers 2) 12 Detector Pre-Amp assemblies 3) 141 Thermistor component assemblies 4) 48 I/O interface boards 5) 12 Transistor/diode assemblies 6) 18 Card cage assemblies 7) 12 Signal processor assemblies 8) 78 Cable assemblies 9) 2 Power control monitor assemblies 10) 10 Power relay assemblies 11) 420 PRT Terminal boards Included in each item above is all hardware ECN incorporation and all rework and retest. SOW Ref: Para 1.1 Para 2.3 Para 2.5 Para 2.7

FireSat Truss Assembly

- The Truss assembly is a key part of the FireSat spacecraft secondary structure
- It is at Level 5 of the FireSat Spacecraft contractor's WBS



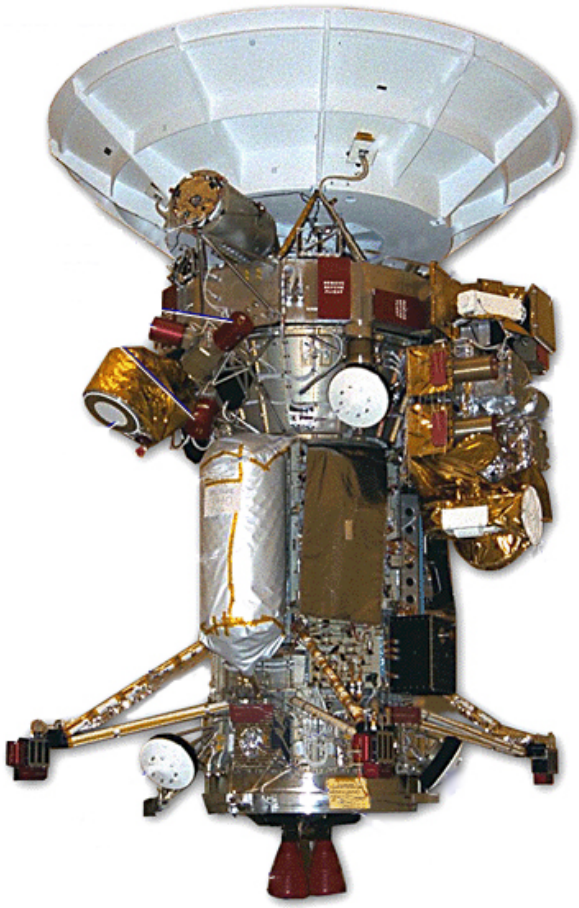
FireSat Decomposition



PACER
WBS Exercise

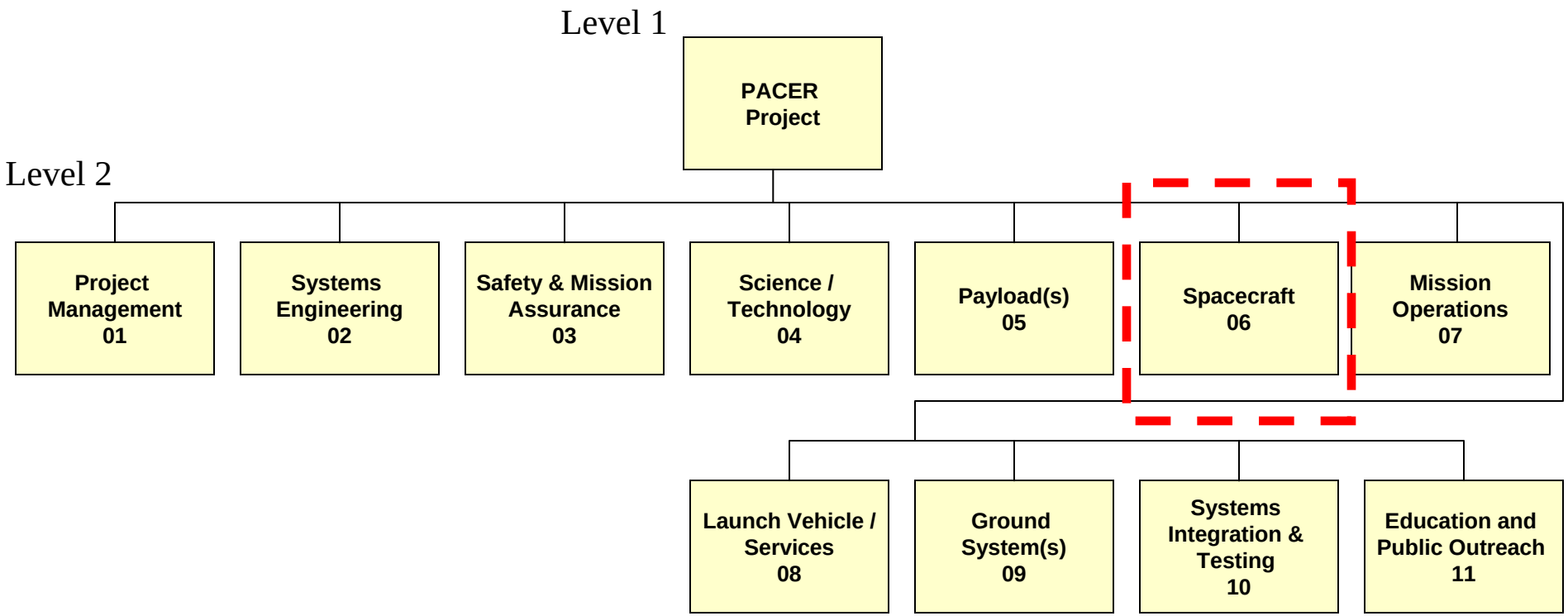
PACER Spacecraft WBS Exercise

- Your team plans to bid on the PACER spacecraft bus development
- In order to prepare a schedule and cost estimate, this second level of the project WBS needs additional detail
- Assuming “Spacecraft Bus” is level 2 of the WBS, pick one or two subsystems and develop the WBS to level 4 – be prepared to discuss your approach with the rest of the class

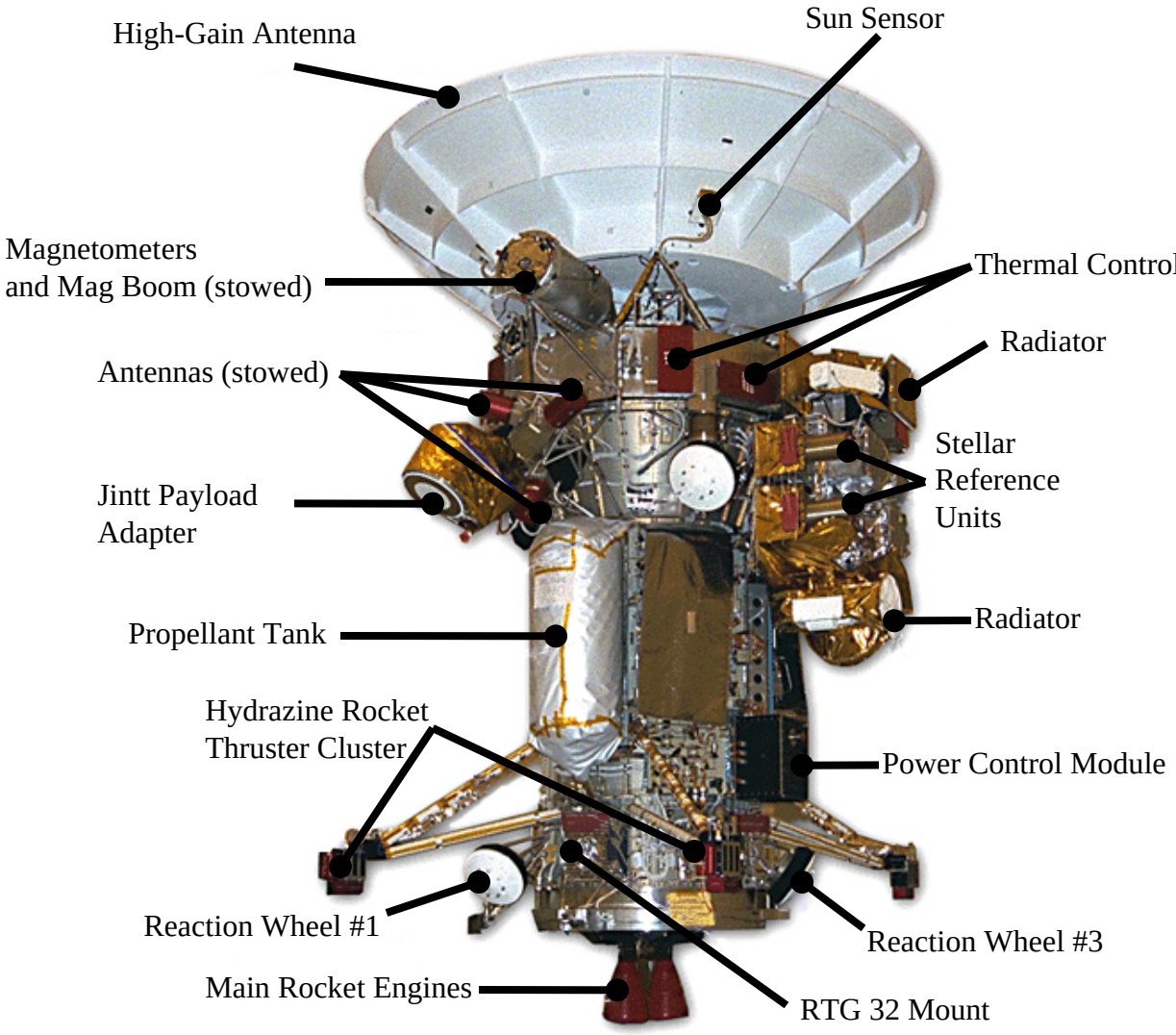


PACER Configuration

PACER Project Level 1 and 2 WBS



PACER Project Level 1 and 2 WBS



Not Shown
- Torquer Bars
- Batteries
- Harness
- Command & Data Handling Unit
- Structure
- Transponder
- Electrical Distribution Unit
- Heat Pipes
- Antenna Deployment Mechanism
- Magnetometer Deployment Mechanism

PACER Spacecraft Subsystems

- Communications
- Power
- Electrical
- Flight Software
- Reaction Control/Propulsion
- Attitude Control
- Command & Data Handling
- Structure
- Thermal
- Contamination
- Mechanisms/Deployables

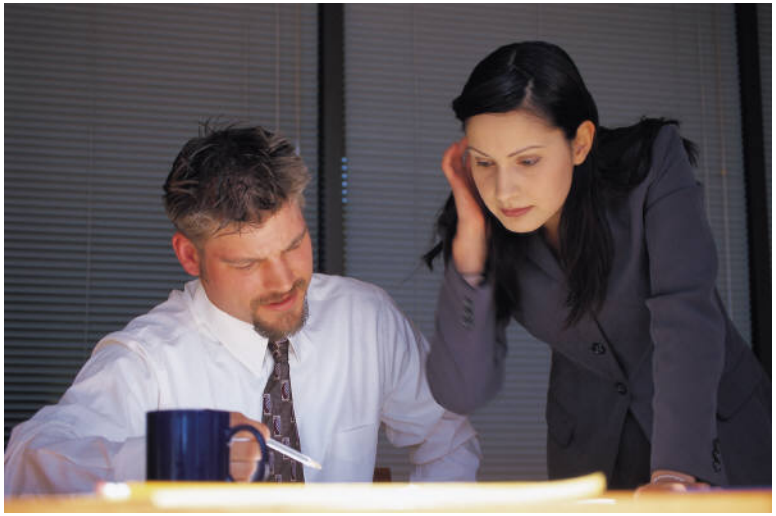
PACER Spacecraft WBS Worksheet

Project Scheduling

How long will it take to finish my project?
What is a critical path?
How does the budget relate to the schedule?

The Success-Oriented Schedule

- The supplier for a key component for your subsystem says that his schedule is “success-oriented”
- Is that a good or bad thing?



Schedule Pressures

United States Government Accountability Office

GAO

Testimony

Before the Subcommittee on Space and Aeronautics, Committee on Science and Technology, House of Representatives

For Release on Delivery
Expected at 10:00 a.m. EDT
Thursday, April 3, 2008

NASA

Ares I and Orion Project Risks and Key Indicators to Measure Progress

Statement of Cristina T. Chaplain, Director
Acquisition and Sourcing Management

G A O
Accountability * Integrity * Reliability

GAO-08-186T

" There are considerable schedule pressures facing both the Ares I and Orion projects. These are largely rooted in NASA's desire to minimize the gap between the retirement of the space shuttle and availability of the new vehicles. Because of this scheduling goal, NASA is planning to conduct many interdependent development activities concurrently-meaning if one activity should slip in schedule, it could have cascading effects on other activities. Moreover, some aspects of the program are already experiencing scheduling delays due to the fact that high-level requirements are still being defined. …

Our Prior work has shown that concurrent development, especially when new technologies are involved, increases the risk that significant problems will be discovered as the systems' designs are integrated that could result in cost and schedule delays. NASA's schedule leaves little room for the unexpected. If something goes wrong with the development of the Ares I or the Orion, the entire Constellation Program could be thrown off the course and the return to human spaceflight delayed."

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Schedule Management Case Study

"Whatever happened to the Integrated Master Schedule?"

(separate handout)

Time/Schedule Management

Project Schedule Management includes the processes required to help ensure timely completion of the project:

- Activity Definition - what needs to be done
- Activity Sequencing - project logic
- Activity Duration Estimating - how long the activity will take to complete
- Schedule Reserve Planning - just in case
- Schedule Development - creating the intended timetable
- Schedule Status Accounting, Data Maintenance and Updating - getting the facts
- Schedule Analysis - understanding results
- Schedule Performance Reporting - how are we doing and where are we going
- Schedule Control - managing change, taking action

It also involves teamwork and open communication.

Purpose and Benefits of the Project Schedule

The purpose of a schedule is to provide a tool that identifies what the project team intends to do, and when it intends to do it.

The schedule aids in:

- Integrating the project's activities into a logical flow
- Setting the intended timetable for achieving the project's objectives
- Establishing a time-phased budget
- Measuring performance
- Identifying potential problems early
- Understanding the time impact of changes
- Forecasting how long it will take to finish the project
- Preparing "what-if" analyses and "workaround" plans in response to new conditions

Four Key Schedule Terms to Remember

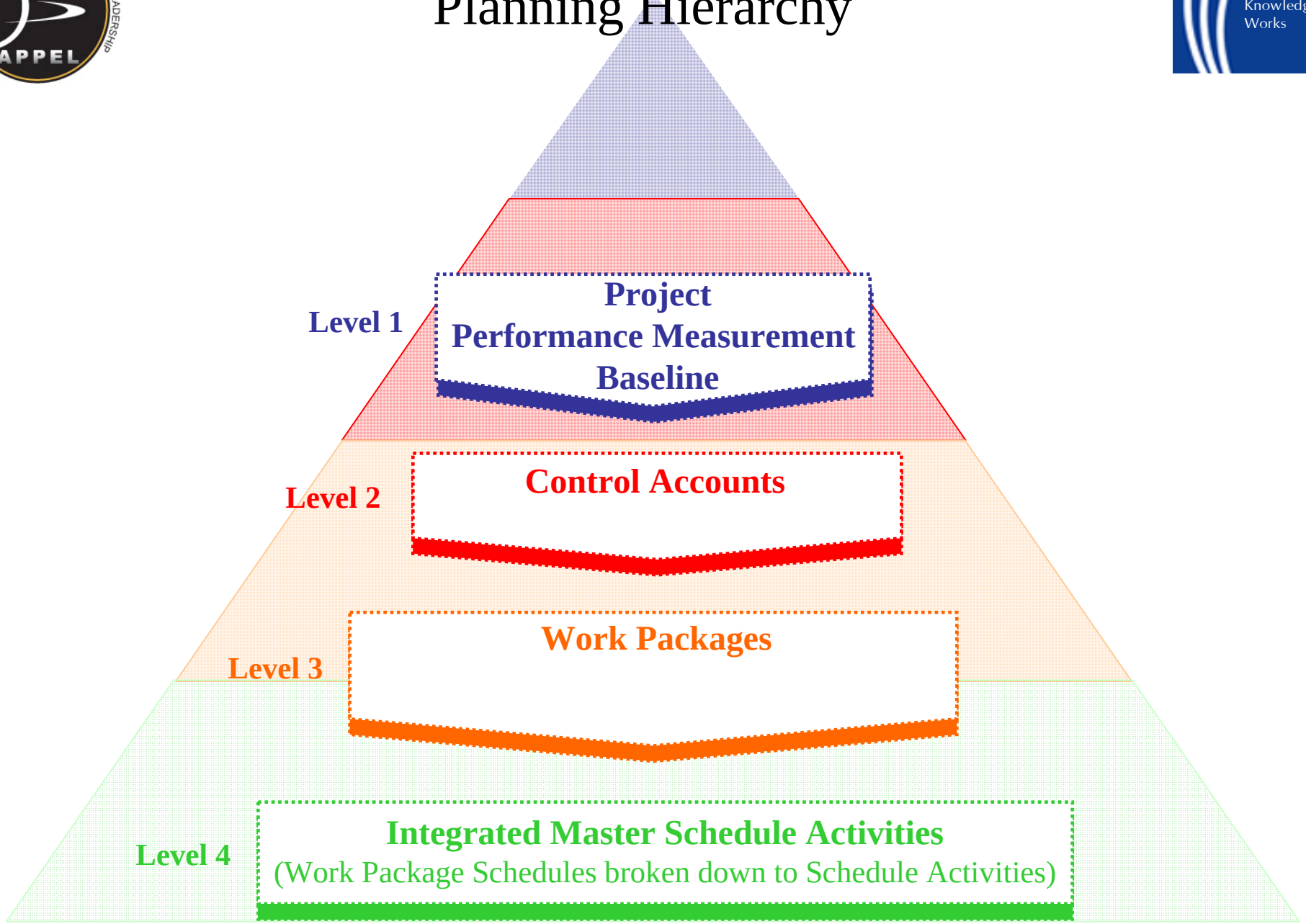
- Integrated Master Schedule*: "An integrated set of schedule data that reflects the total project scope of work as discrete and measurable tasks/milestones that are time phased through the use of task durations, interdependencies, and date constraints and is traceable to the WBS."
- Total Slack: Amount of duration an activity can be delayed before it impacts the target finish date of the project
- Critical Path: The longest sequential path through a logic network, from beginning to end, that defines the earliest a project can finish.
  - Path with the longest overall duration
  - Path with the least amount of total slack
- Schedule Reserve: A pre-planned amount of activity duration incorporated into the project schedule. Used as a protective cushion, or buffer, for absorbing the time impact of risks or problems with in-scope work. Reserve is represented as a "dummy activity" in the logic network.

*Source: NPR7120.5D

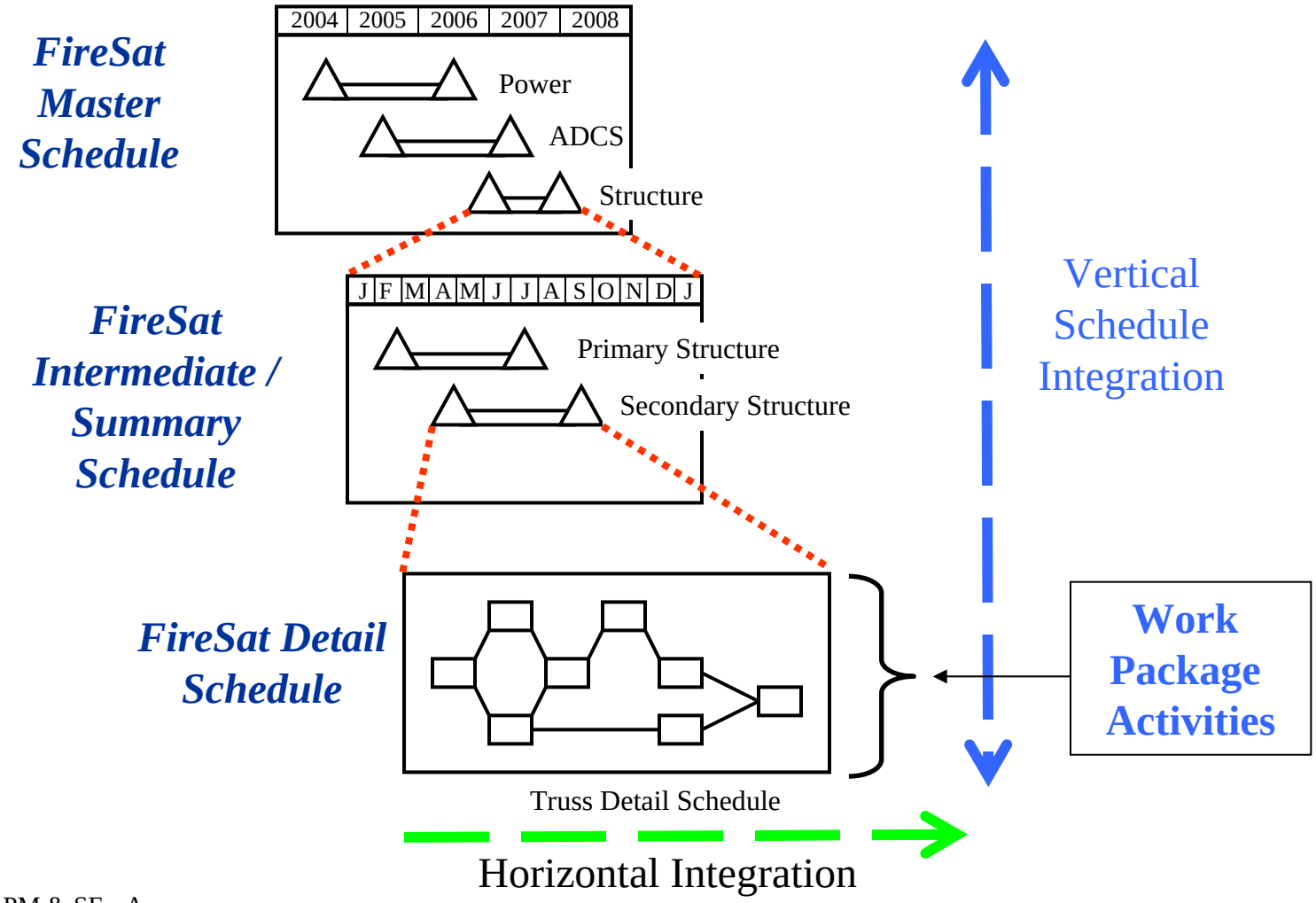
Activity Definition

- Activity Definition is the process of identifying the activities which must be performed in order to produce the project's deliverables and meet its objectives
- The output of activity definition is the activity list

Planning Hierarchy



Schedule Hierarchy

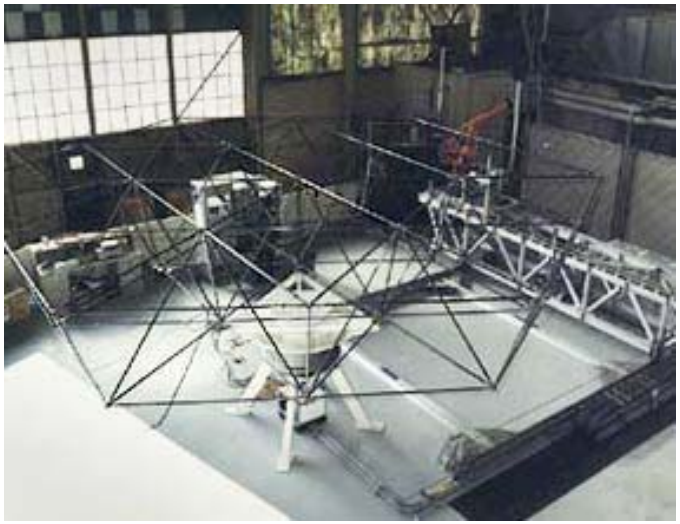


FireSat Truss Final Assembly Work Package

- Let's identify the activities that the manufacturing department needs to perform to accomplish the scope in the "Truss Final Assembly" work package.
- Typically, a work order is needed to authorize manufacturing effort. For a job like the truss, the necessary parts are staged before assembly operations begin. A weight check is also performed after the Truss members are assembled. Once assembled, the truss is delivered to the quality control department for inspection.

FireSat Truss Final Assembly Activity List

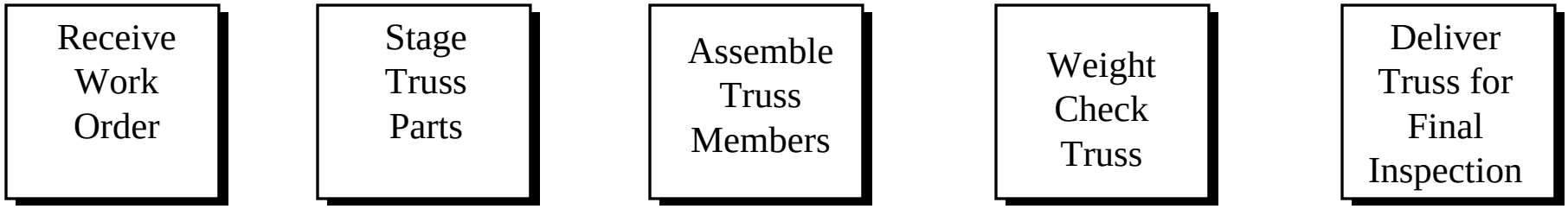
1) Receive work order
2) Stage Truss parts
3) Assemble Truss members
4) Weight check Truss
5) Deliver Truss for final inspection



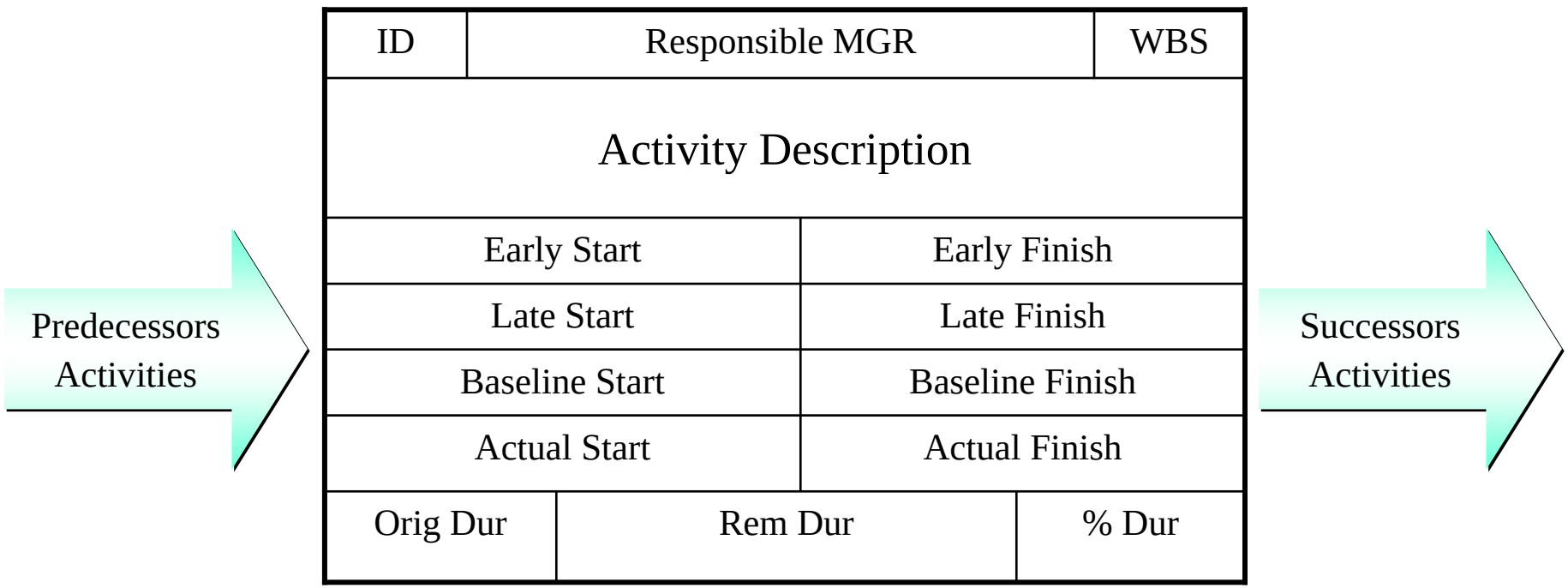
Why can't I just have one activity in the schedule for the "Truss Final Assembly" Work Package?

Activities and Milestones Become "Nodes" in Logic Network

FireSat Truss Final Assembly

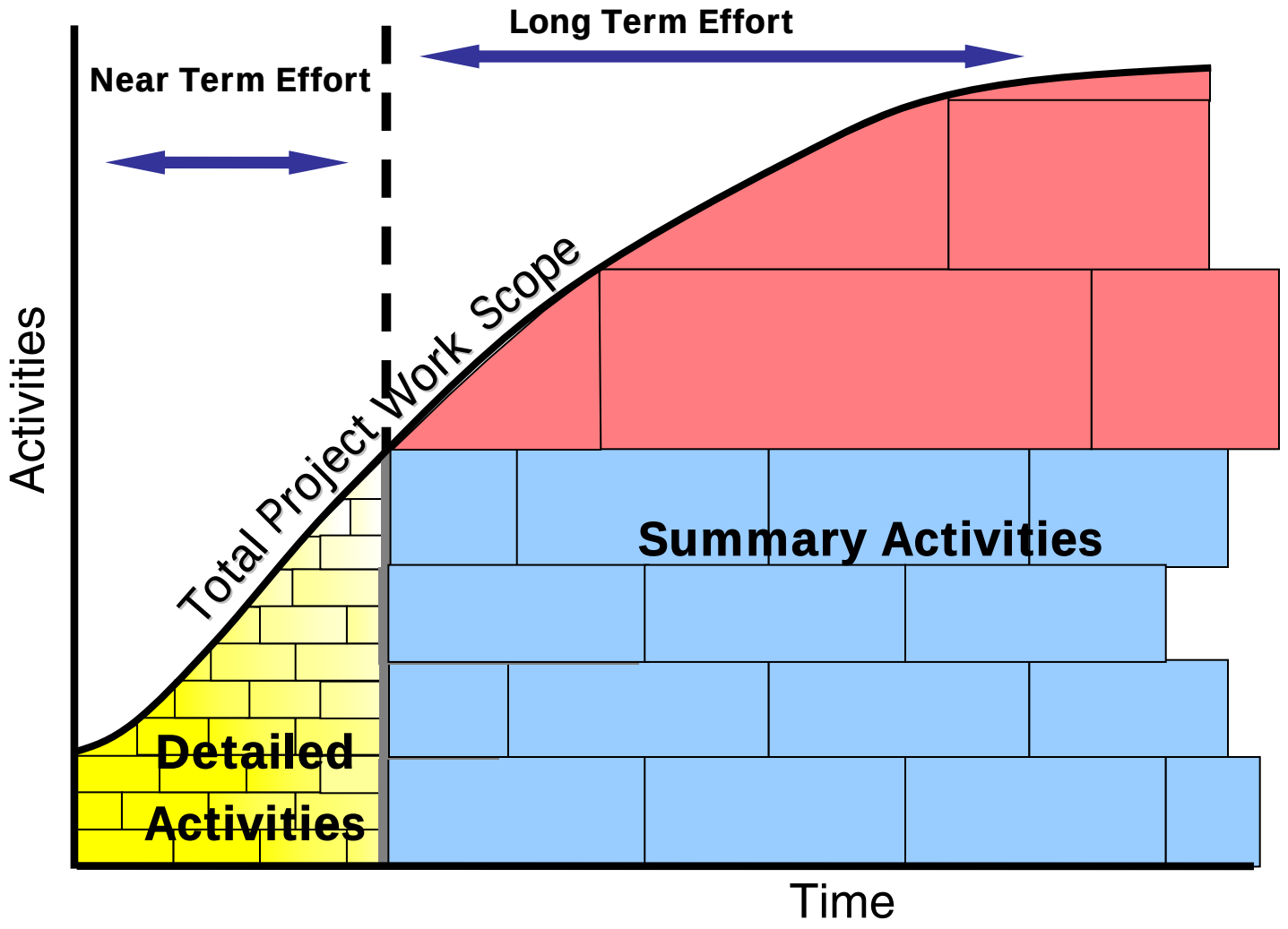


Activity Attributes/Characteristics



Example of common activity attributes

Rolling Wave Scheduling

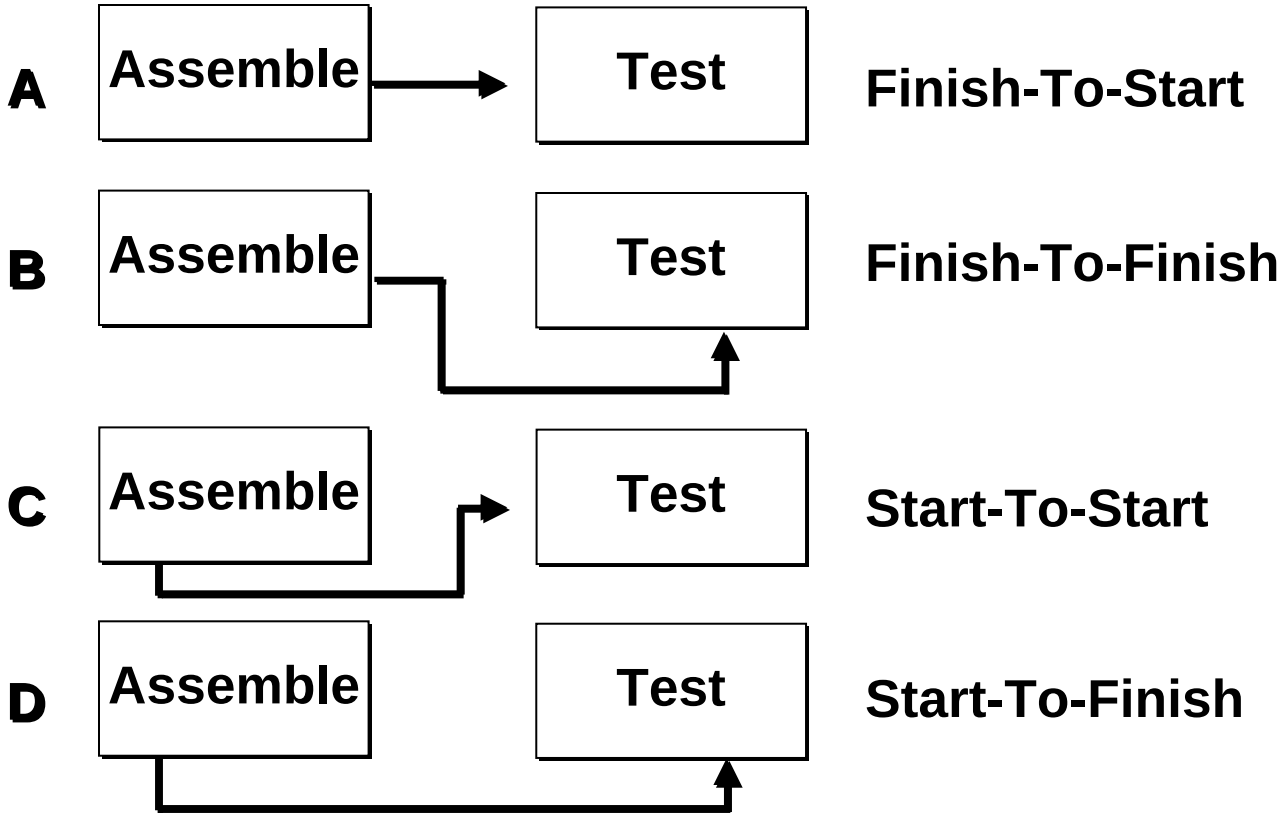


Activity Definition Rules of Thumb

- Activities should be discrete enough to determine Finish-to-Start dependencies
- Activities should be specific enough to document receivables and deliverables between organizations
- Activities should be precise enough to measure progress
- Near-to-intermediate term activities should not exceed one month in duration
- Too many one or two day activities lead to time-consuming updates
- More activity detail if a small proportion of the total number of project activities account for a large proportion of the project budget
- Decompose integration & test flow into activities early to identify when hardware and software deliverables are needed
- More activity detail for work scope with higher risk

Project Logic: Think About It

The "Test" activity cannot start until the "Assemble" activity is finished. Which dependency best represents the precedence relationship or logic between these two activities?



Activity Sequencing

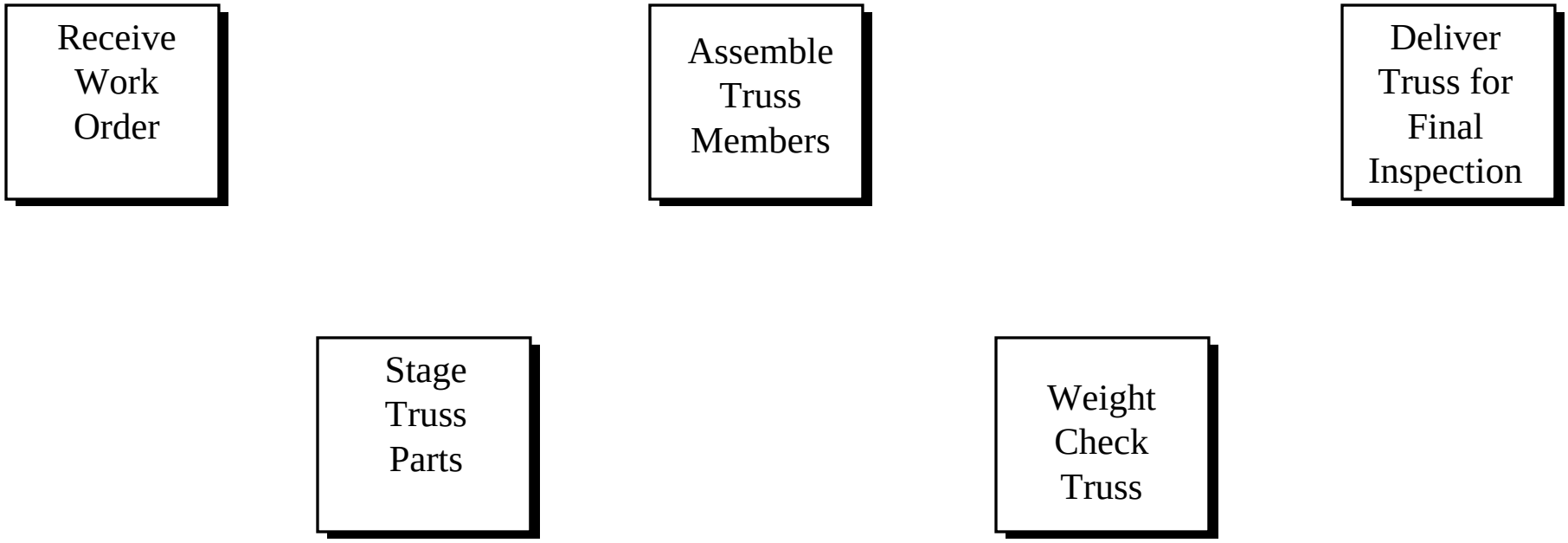
- Activity Sequencing is the process of establishing the project logic by identifying the dependency relationships between the project's activities.

Dependencies

- Mandatory Dependencies
  - Work must flow a specific way (hard logic)
  - e.g. design before fab
- Discretionary Dependencies
  - Work desired to flow a certain way, but alternate ways are available (soft logic)
  - e.g. ship support equipment in advance of instrument vs. ship both together
- External Dependencies
  - Relationship between project and non-project activities
  - e.g. receive software model from Department of Energy
- Phantom/Ghost Dependencies
  - Undefined relationships
- Resource Dependencies
  - Resource limiting relationships between activities
  - e.g. crew unloads container 2 after unloading container 1

Activities and Milestones Become "Nodes" in Logic Network

FireSat Truss Final Assembly



Draw the dependencies between the Truss Final Assembly work package activities

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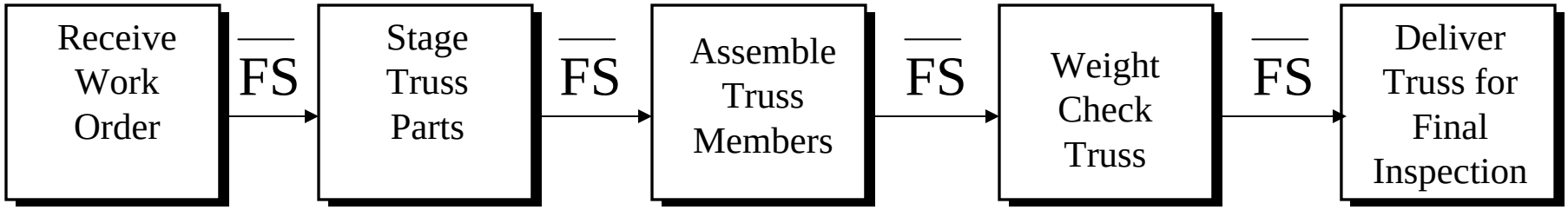
FireSat Project Logic

FireSat Truss Final Assembly



$\overline{FS}$ = Finish - To - Start

Activity Sequencing Rules-of-Thumb

- One start and one finish activity/milestone for the IMS/ Logic Network
- Use Finish-to-Start dependencies whenever feasible
- Avoid leads and lags if an activity can serve the same function
- Eliminate redundant relationships
- Only use constraints when work sequence is influenced by factors external to the project or to document an assumption (e.g. delivery from foreign partner)

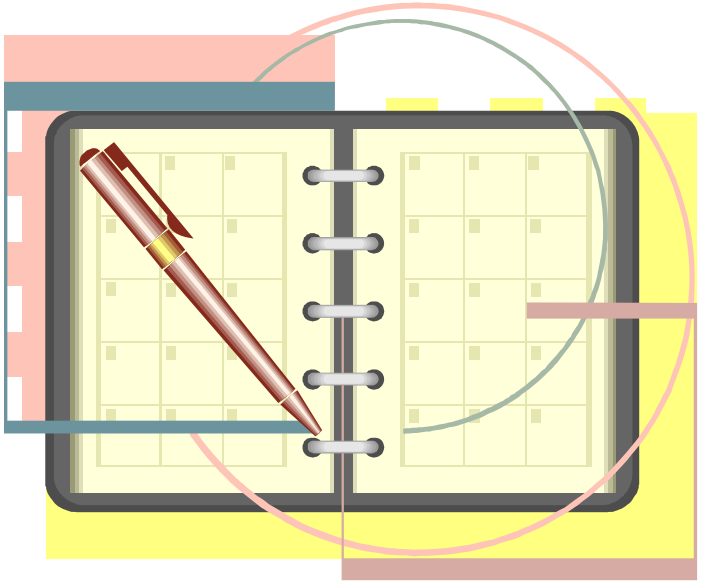
Will the Real Duration Please Stand Up?

- Sally must provide her duration estimate for the “EMI” activity to the project manager next week.
- Based on her experience, the test can most likely be accomplished in 5 work days.
- But it could last as long as 10 days if anomalies occur, or if all goes smoothly, finish in 3 days.
- Which duration should Sally use?

“Sally”

Activity Duration Estimating

- Activity Duration Estimating is the process of determining the *realistic* number of work periods required to complete each activity.



Resource Requirements, Availability and Utilization Influence Activity Durations

Duration:
Actual or estimated amount of time required to complete an activity.

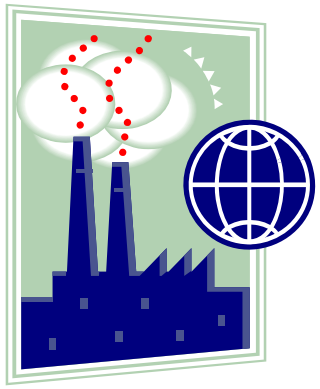
Effort:
Amount of work Involved in performing an activity; typically expressed in units such as hours for labor

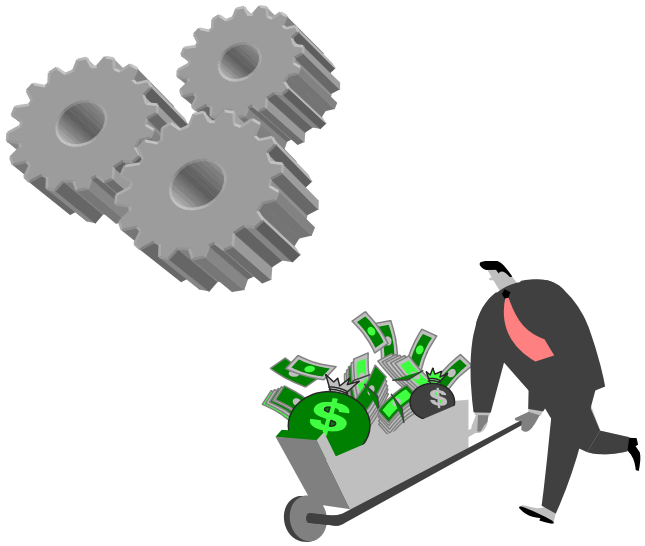
Resources:
People, equipment, time, material, facilities, dollars, etc. needed to perform the work/effort

A realistic, achievable schedule must take into account the resources required to perform the work – especially those that are scarce, shared or difficult to obtain.

Resource Identification

- Resource Identification: the selection and definition of resource categories that are needed to accomplish the project's activities:
  - Funding
  - Equipment
  - Facilities
  - Data
  - Staffing/labor
  - Materials
  - Time





Resource Allocation

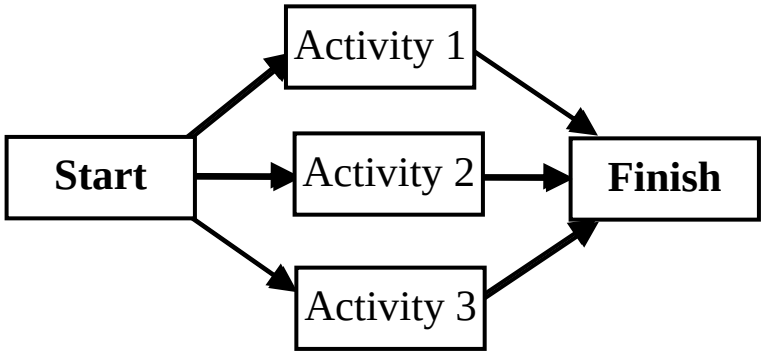
- Resource Allocation: once identified, the resources required to accomplish the project's activities are assigned and then "loaded" with the quantity or value of the resources estimated to accomplish them:

- Activity "Assemble Truss Members"

  Assembly Technician II 160 hours

Resource Availability can Shorten or Lengthen the Overall Project Duration

IF



All 3 activities can be performed in parallel, and each has a one day duration, how long will the project take to finish?

_____ **Day(s)**

BUT

- Only Joe can perform activities 1 & 2
- Joe can only accomplish one activity per day
- Sally can complete activity 3 in one day

THEN

How many days will it take to finish the project?

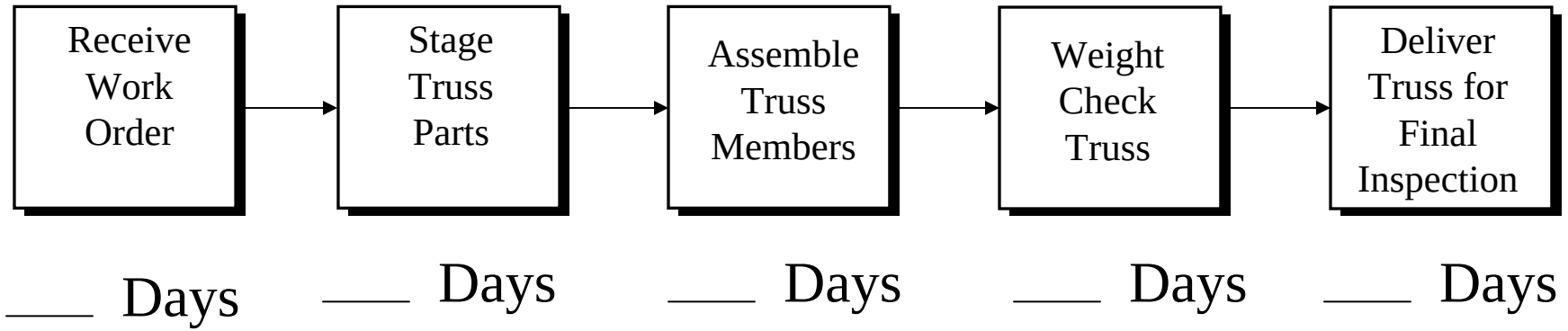
_____ **Day(s)**

FireSat Activity Duration Estimating

- Assumptions
  - "Receive work order" is an event
  - "Deliver Truss for Final Inspection" is an event
  - It typically takes 16 hours to "Stage Truss Parts" for a job like FireSat
    - One production control coordinator is available for this activity on a 1-8-5 basis (1 shift, 8 hours per day, 5 days per week)
  - 160 hours of assembly effort is needed to "Assemble Truss Members"
    - Two "Assembly Technician II" resources are available for our job
    - Manufacturing operates on a 1-8-5 basis
  - One work day is usually planned for a "weight check" operation of this type
  - No work occurs during the holiday plant shutdown (December 24 – January 1)

FireSat Activity Duration Estimating

- Based on the assumptions on the previous page, what are the activity durations in working days for the FireSat "Truss Final Assembly" activities?



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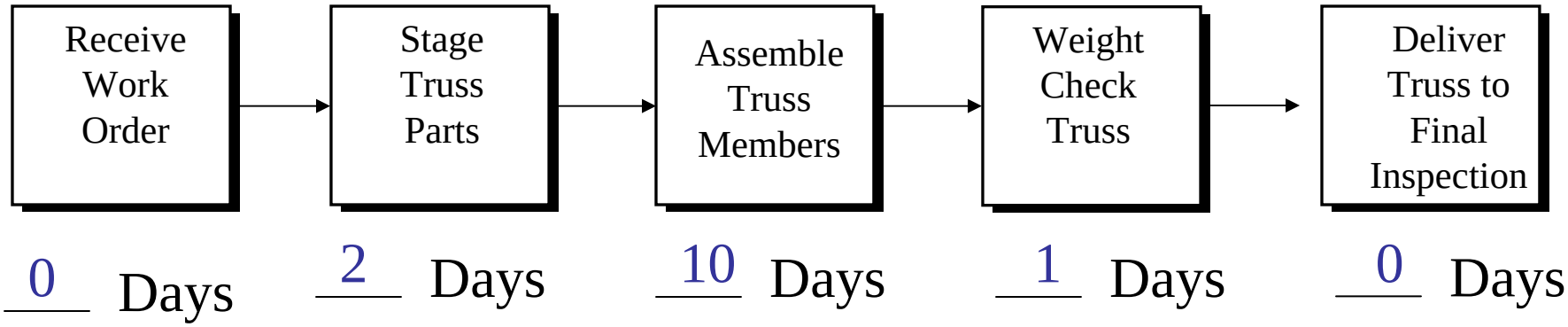
FireSat Activity Duration Estimating

- Did you get these durations?



0 days + 2 days + 10 days + 1 day + 0 days = 13 days total duration

Duration Estimating Methods

Estimating Method	Approach	Reliability
Expert Judgment	Estimate is based on the expertise, knowledge or experience of someone familiar with the activity	Moderate
Analogous	Actual duration from a similar activity used as the basis for the new activity duration	Moderate
Bottoms-Up / Grassroots	Decomposition of activities into lower level tasks which are estimated and then aggregated at higher levels	High
Parametric	Duration derived from a arithmetical relationship among variables	Moderate-to-High
Brainstorming	Project team guesses durations based on a combination of factors (gut feel, prior experience, historic actuals)	Low
Expected Value / 3-Point	Average of activity's most likely, optimistic and pessimistic duration estimates	High
Standards Application	Well-established, historically validated durations for routine or procedurally-based activities or operations	High

Activity Duration Estimating Rules-of-Thumb

- Durations should be estimated by the person responsible for the activity (when feasible); have one or two others also estimate the duration
- Consider using 3-point estimates to characterize uncertainty/risk in the activity
- Compare estimated durations to actual durations from similar activities on previous projects
- Review duration estimates with experts who have experience with similar types of work
- Near-to-intermediate term durations should not exceed one month
- “Long” durations render percentage complete determination little more than guesswork
- Duration estimates should not be
  - Padded by the estimator to hide reserve
  - Reduced by the estimator to “take a challenge” or “buy in”
  - Arbitrarily cut by management
- Always consider availability of key resources

Carefully Consider Activity Constraint Types

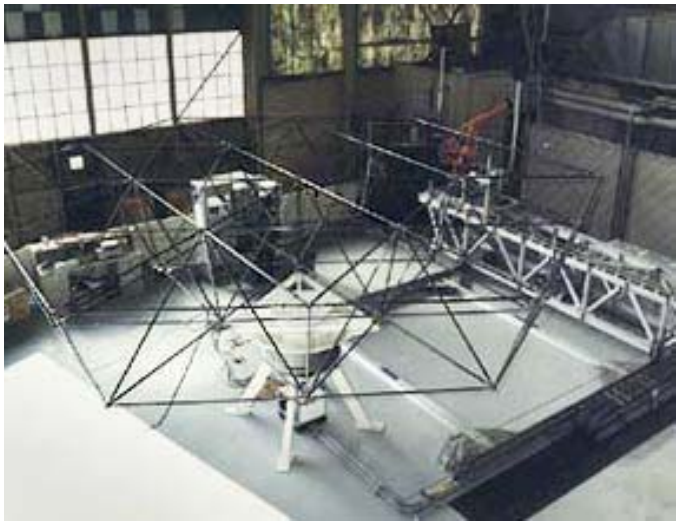
Restrictions, deadlines or limitations on an activity's start or finish dates:

ASAP: As Soon As Possible*
ALAP: As Late As Possible
SNET: Start Not Earlier Than
FNET: Finish Not Earlier Than
SNLT: Start Not Later Than
FNLT: Finish Not Later Than
MSO: Must Start On
MFO: Must Finish On

* Most Realistic Constraint

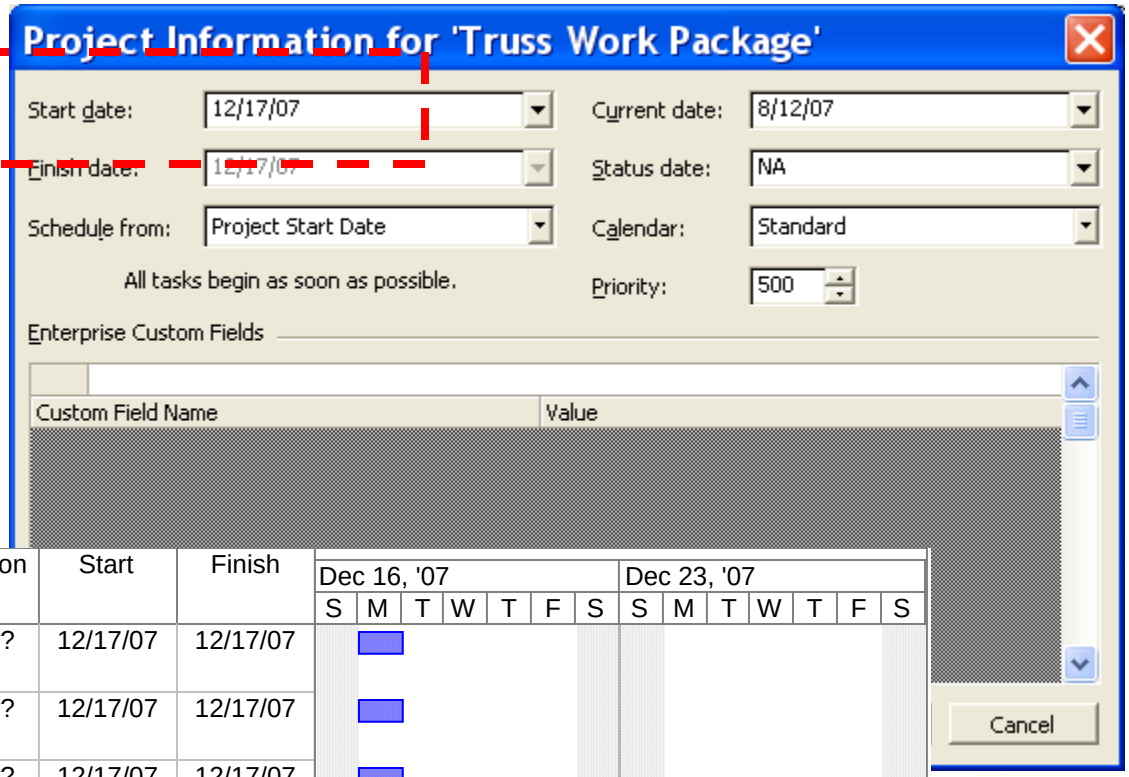
FireSat Schedule Development

- Now that we have our activities, durations and logic, let's develop the "Truss Final Assembly" work package schedule
- Assume a December 17, 2007 start date



Truss Final Assembly Work Package Activities and Start Date

Assume Work Package starts on 12/17/07

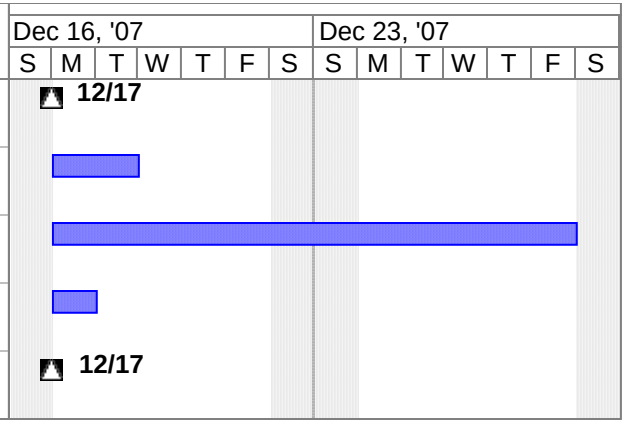


Truss Work Package Activities

ID	Task Name	Duration	Start	Finish
1	Receive work order	1 day?	12/17/07	12/17/07
2	Stage truss parts	1 day?	12/17/07	12/17/07
3	Assemble truss members	1 day?	12/17/07	12/17/07
4	Weight check truss	1 day?	12/17/07	12/17/07
5	Deliver truss to final inspection	1 day?	12/17/07	12/17/07

Input Activity Durations

ID	Task Name	Duration	Start	Finish
1	Receive work order	0 days	12/17/07	12/17/07
2	Stage truss parts	2 days	12/17/07	12/18/07
3	Assemble truss members	10 days	12/17/07	12/28/07
4	Weight check truss	1 day	12/17/07	12/17/07
5	Deliver truss to final inspection	0 days	12/17/07	12/17/07

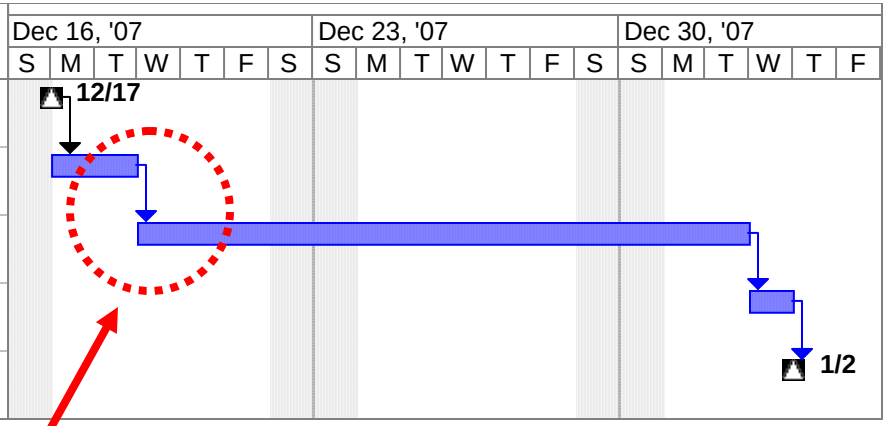


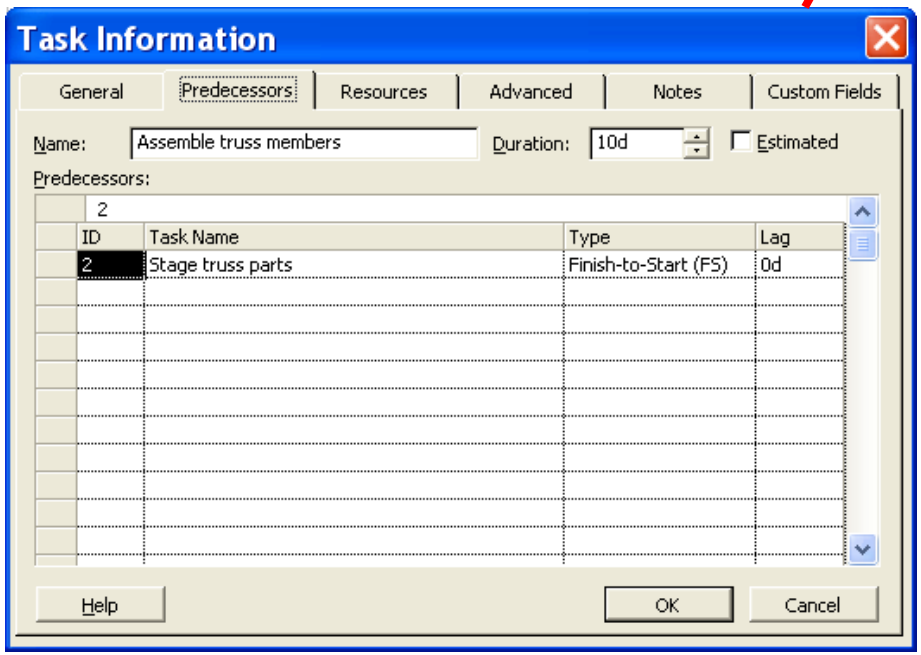
Activity duration estimates based on resource requirements

How were these determined?

Incorporate Activity Logic

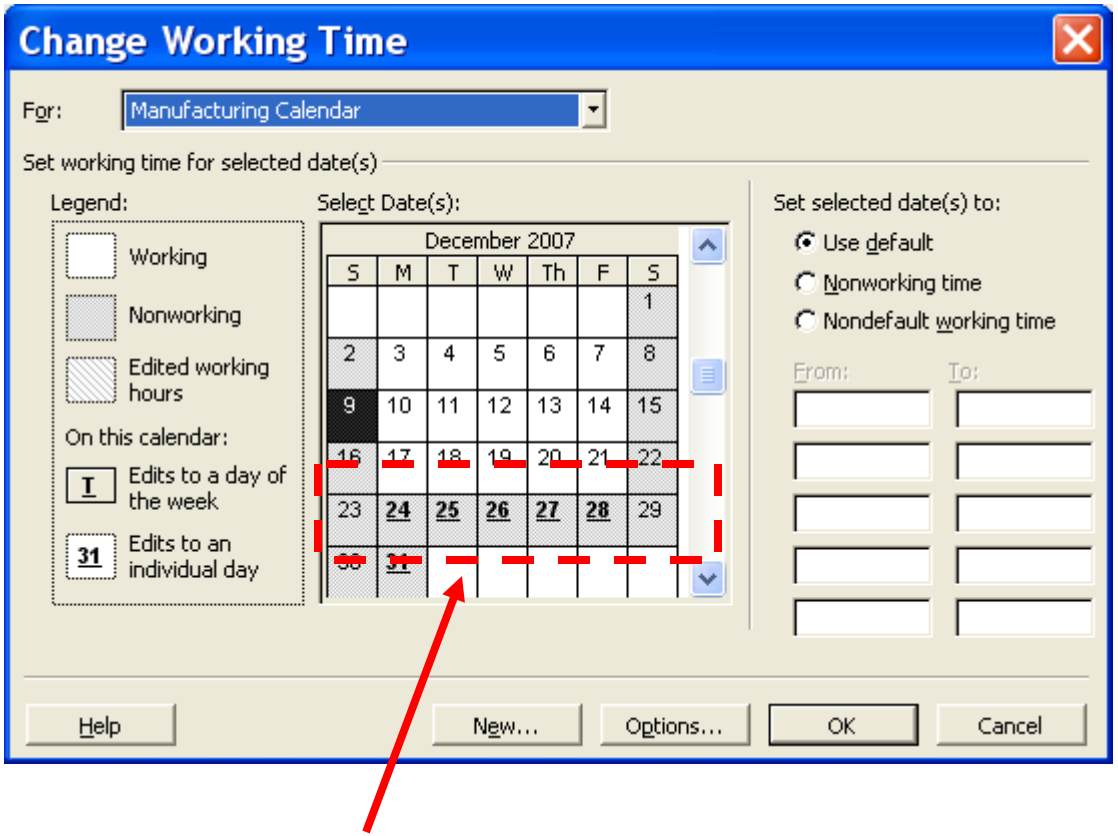
ID	Task Name	Duration	Start	Finish
1	Receive work order	0 days	12/17/07	12/17/07
2	Stage truss parts	2 days	12/17/07	12/18/07
3	Assemble truss members	10 days	12/19/07	1/1/08
4	Weight check truss	1 day	1/2/08	1/2/08
5	Deliver truss to final inspection	0 days	1/2/08	1/2/08





What effect does the incorporation of project logic have on the Truss Final Assembly Work Package schedule?

Don’t Forget Project Calendars

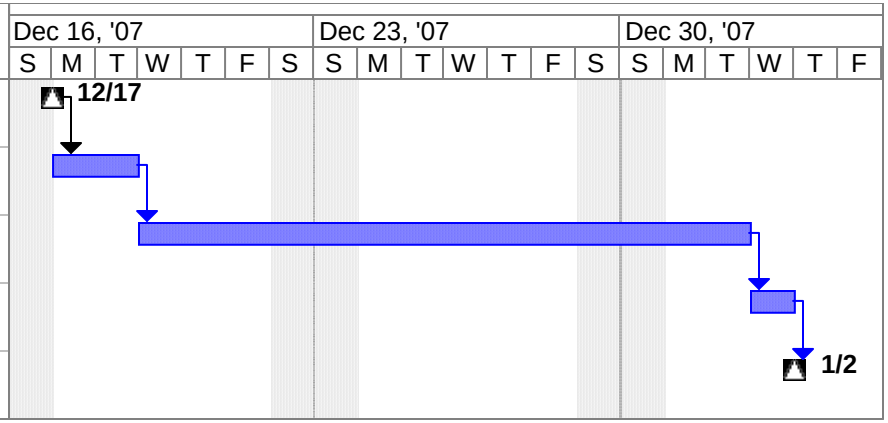


Non-work periods identified for manufacturing during holiday shutdown

Remember the Holiday Shutdown

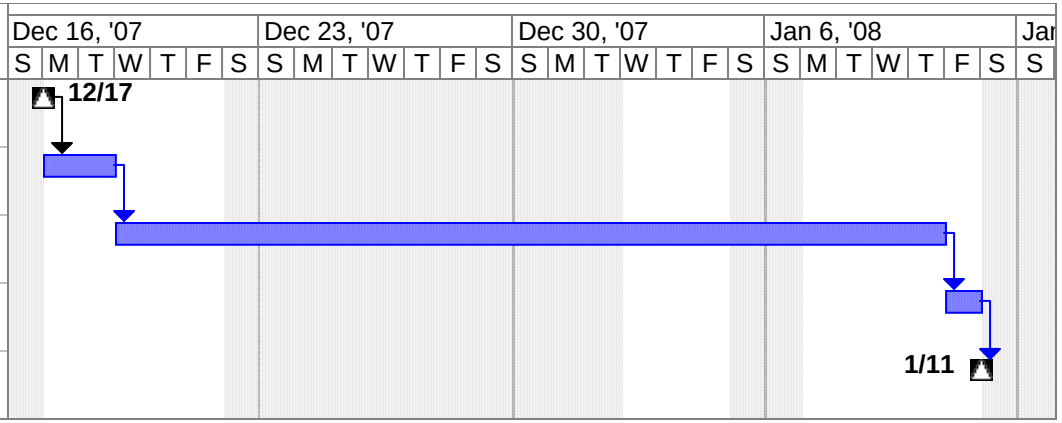
Schedule Without Holiday Shutdown

ID	Task Name	Duration	Start	Finish
1	Receive work order	0 days	12/17/07	12/17/07
2	Stage truss parts	2 days	12/17/07	12/18/07
3	Assemble truss members	10 days	12/19/07	1/1/08
4	Weight check truss	1 day	1/2/08	1/2/08
5	Deliver truss to final inspection	0 days	1/2/08	1/2/08



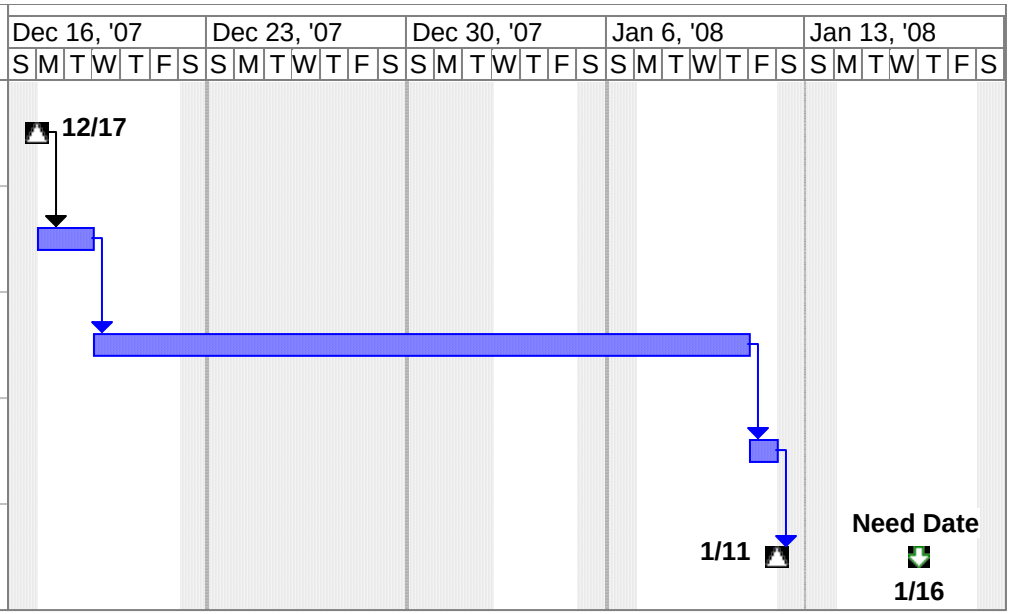
Schedule With Holiday Shutdown

ID	Task Name	Duration	Start	Finish
1	Receive work order	0 days	12/17/07	12/17/07
2	Stage truss parts	2 days	12/17/07	12/18/07
3	Assemble truss members	10 days	12/19/07	1/10/08
4	Weight check truss	1 day	1/11/08	1/11/08
5	Deliver truss to final inspection	0 days	1/11/08	1/11/08



Understanding Total Slack

ID	Task Name	Duration	Start	Finish	Total Slack
1	Receive work order	0 days	12/17/07	12/17/07	3 days
2	Stage truss parts	2 days	12/17/07	12/18/07	3 days
3	Assemble truss members	10 days	12/19/07	1/10/08	3 days
4	Weight check truss	1 day	1/11/08	1/11/08	3 days
5	Deliver truss to final inspection	0 days	1/11/08	1/11/08	3 days

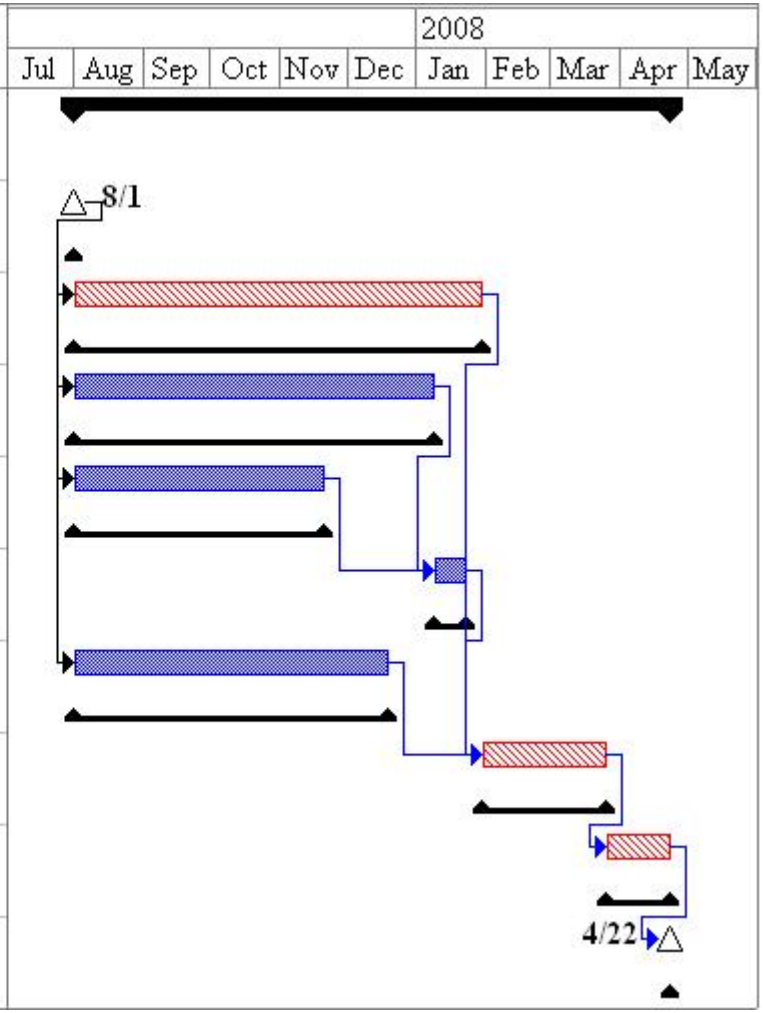


The truss is needed for the start of the FireSat spacecraft structure assembly by January 16, 2008

The +3 days of total slack is the number of work days the truss delivery can be delayed before it impacts the need date of January 16th

Critical Path, Slack & Reserve

ID	Task Name	Duration	Free Slack	Total Slack
1	**SCS Project**	**190 days**	**0 days**	**0 days**
2	Award	0 days	0 days	0 days
3	Subsystem A	130 days	0 days	0 days
4	Subsystem B	115 days	0 days	5 days
5	Subsystem C	80 days	35 days	40 days
6	B-C Special Test	10 days	5 days	5 days
7	Subsystem D	100 days	30 days	30 days
8	System I&T	40 days	0 days	0 days
9	Schedule Reserve	20 days	0 days	0 days
10	Delivery	0 days	0 days	0 days



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Schedule Confidence

Schedule

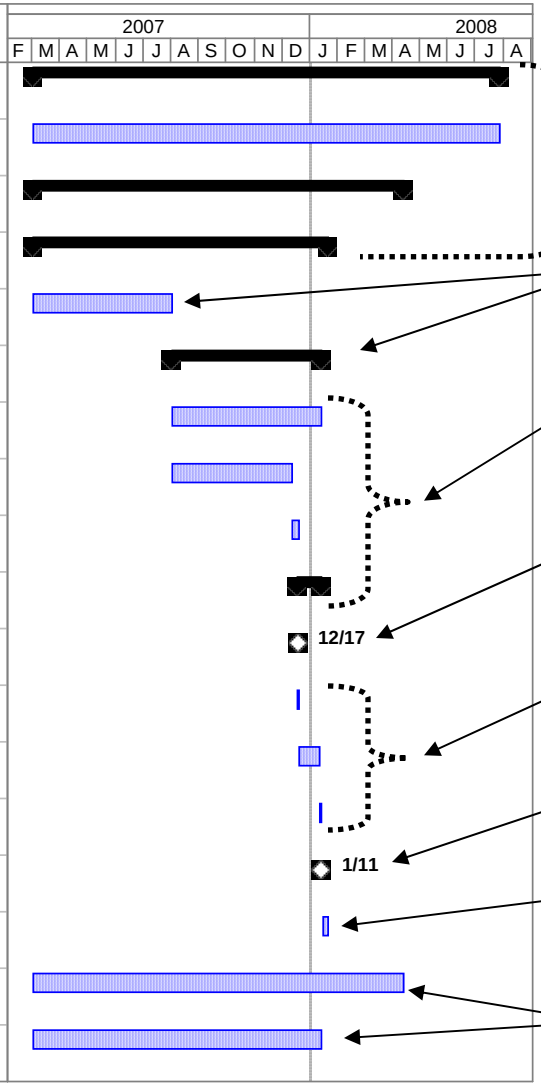
Risk

Analysis

Demo

Schedule Roll-Up Illustrated

ID	WBS	Description
1	**3.1**	**Structures**
2	3.1.1	Primary Structure
3	**3.1.2**	**Secondary Structure**
4	**3.1.2.1**	**Truss**
5	3.1.2.1.1	Truss Mechanical Design
6	**3.1.2.1.2**	**Truss Manufacture**
7	3.1.2.1.2.1	Operations Management
8	3.1.2.1.2.2	Truss Fabrication
9	3.1.2.1.2.3	Kit Truss Assembly
10	**3.1.2.1.2.4**	**Truss Final Assembly**
11	3.1.2.1.2.4.1	Receive work order
12	3.1.2.1.2.4.2	Stage truss parts
13	3.1.2.1.2.4.3	Assemble truss members
14	3.1.2.1.2.4.4	Weight check truss
15	3.1.2.1.2.4.5	Deliver truss to final inspection
16	3.1.2.1.3	Truss Vibration Test
17	3.1.2.2	Base Frame
18	3.1.2.3	Covers



WBS Summaries

Control Accounts

Work Packages

Milestone

Activities

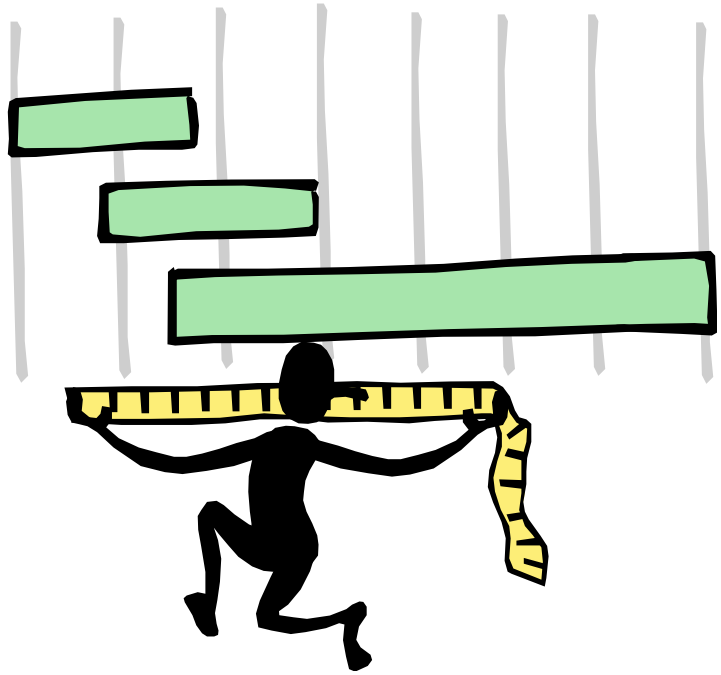
Milestone

Control Account
(or Work Package)

WBS Summaries

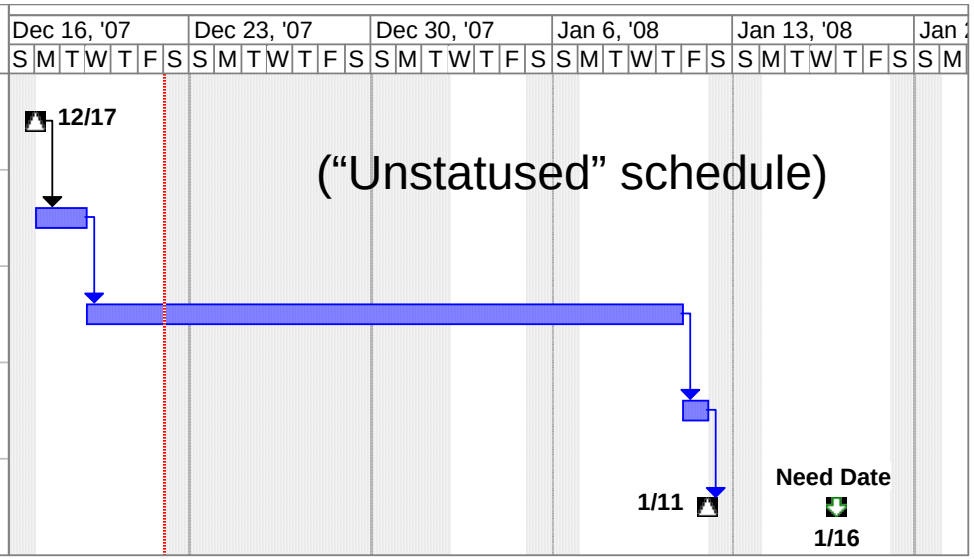
Tracking Schedule Progress

- Factors to consider for activities include
  - Status date
  - Actual start date
  - Actual finish date
  - Remaining duration
  - Percentage complete
  - Estimated completion date
  - Actual duration
  - Comparison of forecast to baseline
  - Earned Value



Updating the Schedule

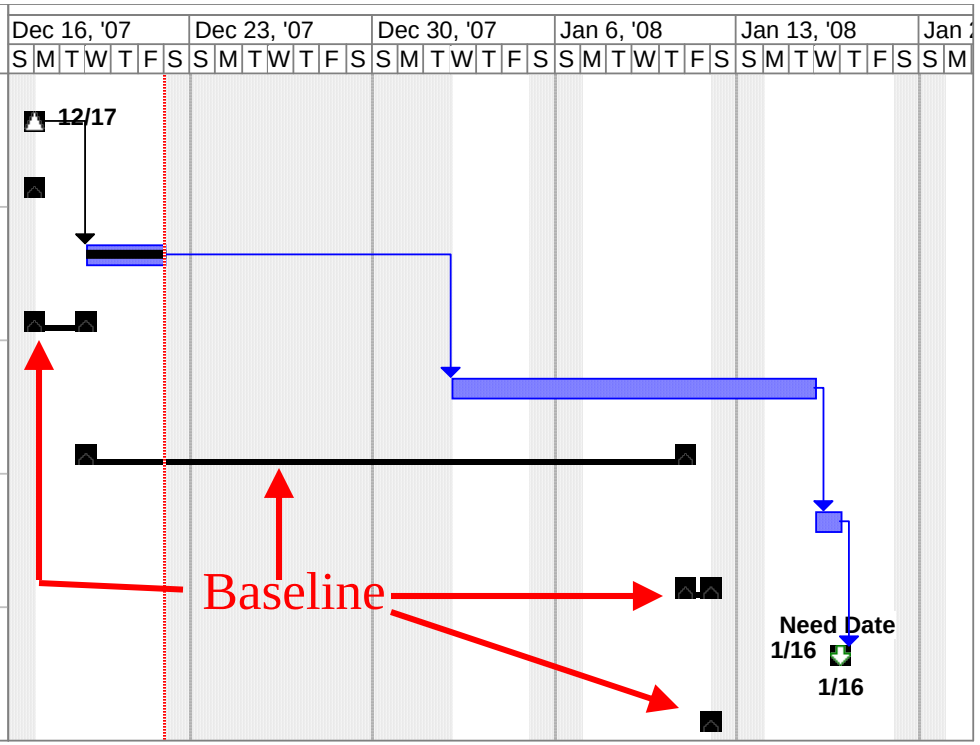
ID	Task Name	Duration	Start	Finish	Total Slack
1	Receive work order	0 days	12/17/07	12/17/07	3 days
2	Stage truss parts	2 days	12/17/07	12/18/07	3 days
3	Assemble truss members	10 days	12/19/07	1/10/08	3 days
4	Weight check truss	1 day	1/11/08	1/11/08	3 days
5	Deliver truss to final inspection	0 days	1/11/08	1/11/08	3 days



- Current Status – As of Friday, December 21
  - The “Stage Truss Parts” activity started 2 days later than planned, and actually took 1 extra day to finish
  - All of the assembly technicians are out sick with the flu and cannot return to work until next week
  - What is the impact on the truss assembly schedule?

Updated Truss Assembly Schedule

ID	Task Name	Duration	Start	Finish	Total Slack
1	Receive work order	0 days	12/17/07	12/17/07	23 days
2	Stage truss parts	3 days	12/19/07	12/21/07	0 days
3	Assemble truss members	10 days	1/2/08	1/15/08	0 days
4	Weight check truss	1 day	1/16/08	1/16/08	0 days
5	Deliver truss to final inspection	0 days	1/16/08	1/16/08	0 days



- Is the truss delivery in trouble?
- What should the Work Package Manager do now?

The Baseline According to NPR 7120.5D

- "Integrated Baseline: The project's technical performance baseline/mission content, technology applications and schedule milestones. The integrated baseline also includes the WBS, WBS dictionary, integrated master schedule, life-cycle cost and work force estimates that are consistent with the program requirements on the project, the project's CADRe (if applicable), and the technical performance baseline/mission content."
- "Project Plan: The document that establishes the project's baseline for implementation, signed by the cognizant Program Manager, Center Director, Project Manager, and the MDAA, if required."
- "Schedule Baseline: Present a summary of the project's integrated master schedule, including all critical milestones, major events, and Agency and Project-level reviews throughout the project life cycle. The summary schedule should include the logical relationships (interdependencies) for the critical milestones, major events, project reviews, and critical paths, as appropriate."

Source: NPR7120.5D

NPR 7120.5D Baseline Schedule Requirements by Project Phase

- Pre-Phase A
  - "A draft Integrated Baseline…that includes…a schedule"
- Phase A
  - "The project's preliminary Integrated Baseline includes a preliminary integrated master schedule"
- Phase B
  - "The project's Integrated Baseline includes the integrated master schedule"
- Phase C
  - "Maintain the Integrated Baseline under configuration management with traceability to the KDP-C approved baseline."

Source: NPR7120.5D

Program Schedule Requirements on Projects

"For each project…identify the project's principal schedule milestones, including PDR, CDR, launch, mission operational-critical milestones, and the planned decommissioning date…If the mission characteristics indicate a greater emphasis is necessary on maintaining either technical, cost, or schedule, then identify which is the most important (e.g., state if the mission is cost capped, or if schedule is paramount as for a planetary mission, or if it is critical to accomplish all of the technical objectives for a technology demonstration mission."

Source: NPR7120.5D

Program Commitment Agreement (PCA) Schedule Commitment

"Identify the following key target milestones for each project in the program such as:

1. Start of Formulation
2. Target date or timeframe for the SDR or MDR/PNAR
3. Target date or timeframe for the PDR/NAR or the start of implementation
4. Start of operations
5. End of prime operations and/or disposal, if applicable
6. Other milestones or time periods as appropriate for a specific program/project"

Source: NPR7120.5D

Schedule Management Plan

2.1.2 Schedule Management Plan

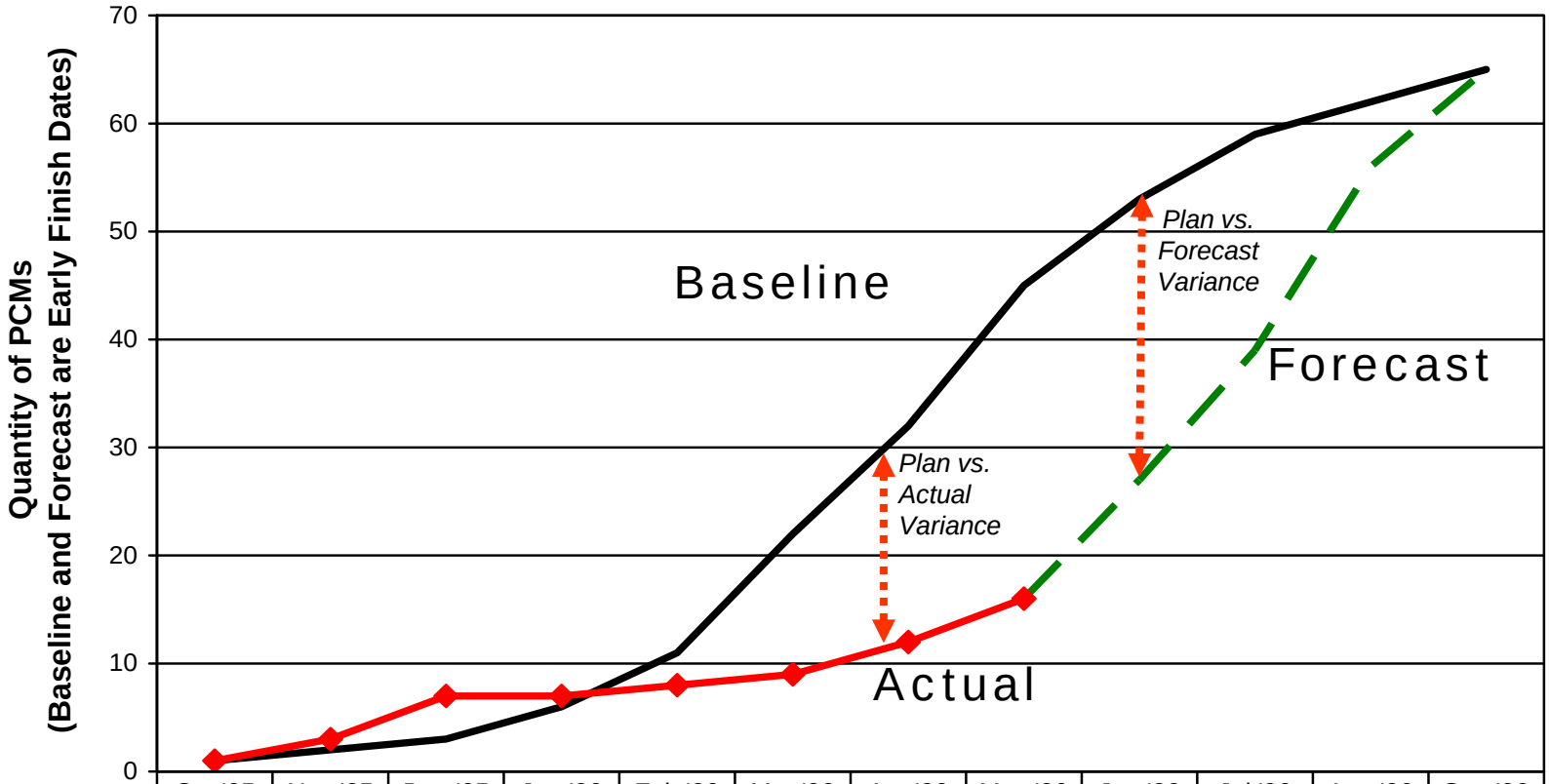
"A Project Schedule Management Plan (SMP) should be prepared early on for each project. The SMP will describe and define the techniques and methods to be used in implementing schedule management processes. The SMP can be a stand-alone plan or a subsidiary component of the Project Plan. However, the Project SMP should be an individual plan subject to document control. The SMP is not intended as a detailed procedure for performing scheduling. Rather, it is a guideline for applying generally accepted project scheduling practices. See Appendix H for a Project SMP Outline Template.

The content of the IMS and the overall SMP approach should be dependent upon how a project is organized. For example, there could be in-house, prime contractor, and/or external partnership activities which will influence the planning process. Additionally, schedule management should be in accordance and integrated with the institutional EVM processes and methodologies on programs/projects."

SOURCE: NASA Schedule Management Handbook, Preliminary REV 14, October 2006

http://evm.nasa.gov/docs/Handbooks/Sched%20Mgmt%20Mar%2007/NASA_SMH_DRAFT_rev14_Oct_2006.doc

Summarizing the Schedule Plan, Performance and Forecast



	Oct '05	Nov '05	Dec '05	Jan '06	Feb '06	Mar '06	Apr '06	May '06	Jun '06	Jul '06	Aug '06	Sep '06
Cum Baseline	1	2	3	6	11	22	32	45	53	59	62	65
Cum Actual	1	3	7	7	8	9	12	16				
Cum Forecast									27	39	56	65

What You Should Know About the Schedule Before It's Baselined:

- Does it contain all of the project work scope?
- What are the assumptions underlying your schedule?
- Are the durations realistic (and are the critical resources available when needed)?
- Is the schedule integrated (horizontally, vertically, and with the budget)?
- What is the critical path (and near critical paths)?
- Where is the risk in the schedule?
- Are the schedule reserves adequate?
- What is the schedule "confidence"?
- Has management "blessed" the schedule?

Ongoing Schedule Analysis Helps Answer:

- When will the project finish?
- Is the schedule still realistic and achievable?
- How are we performing and what is slipping?
- What can past performance tell us about the future?
- How will changes impact the schedule?
- Do we have enough schedule slack and reserve?
- Where is the risk in the schedule?
- Have any of our schedule assumptions changed?
- How are our contractors/suppliers doing?
- How can we get done sooner, recover from this delay, or workaround this problem?

Implementing Project Schedule Control Activities According to NPR 7120.5D

1) "Provide immediate written notice and a recovery plan to the Program Manager and the MDAA if a milestone listed for phases C and D on the project life-cycle chart is estimated to be delayed in excess of six months from the date scheduled in the KDP C-Approved Integrated Baseline."
2) "If trigger points…are breached and upon written notice from the program manager, update the Project Plan per direction received from the Program Manager."

Project Cost Estimating

How much will my project cost?

Cost Estimates

- Cost Estimating
  - Developing an approximation of the likely cost to the performing organization of the resources required to complete project activities
  - The estimate is a prediction of the amount of cost needed to accomplish the effort
  - For NASA projects, the total life cycle cost must be estimated

What is Life-Cycle Cost?

"Life-Cycle Cost (LCC): The total of the direct, indirect, recurring, nonrecurring, and other related expenses incurred, or estimated to be incurred, in the design, development, verification, production, operation, maintenances, support, and disposal of a project. The LCC of a project or system can also be defined as the total cost of ownership over the project or system's life cycle from formulation through implementation. It includes all design, development, deployment, operation and maintenance, and disposal costs."

Source: NPR 7120.5D

A Life Cycle Cost is the Total Cost of a Project

- A Life Cycle Cost Estimate (LCCE) is used for:
  - Budgetary decisions
  - System trades and studies
  - Support of milestone reviews
  - Determination of project viability, appropriate scope and size

Source: NASA Cost Estimating Handbook 2008

Pre-Phase A Cost Estimate Requirements (Concept Studies)

- "Develop and document a *draft* Integrated Baseline for all work to be performed by the project that includes the following:
  - A high-level Work Breakdown Structure (WBS) consistent with the NASA standard space flight project WBS (Appendix G), a schedule, and a rough-order-of-magnitude cost estimate and cost range."

What does "rough-order-of-magnitude" mean?

Source: NPR 7120.5D

Phase A Cost Estimate Requirements
(Concept and Technology Development)

- "Develop and document a *preliminary* Integrated Baseline for all work to be performed by the project, noting the following:
  - Preliminary lifecycle cost estimate that:
    - Is based on the project's technical baseline/mission concept and preliminary integrated master schedule.
    - Uses the latest available full-cost accounting initiative guidance and practices.
    - Includes reserves, along with the level of confidence estimate provided by the reserves, based on a cost-risk analysis.
    - Is time-phased by Government Fiscal Year (GFY) to WBS Level 2."

Source: NPR 7120.5D

Phase B Cost Estimate Requirements
(Preliminary Design and Technology Completion)

- "Develop, document, and maintain a project Integrated Baseline for all work performed by the project noting the following:
  - Baseline life-cycle cost estimate that:
    - Is based on the PDR-technical baseline and integrated master schedule and is expected to include a review of the entire scope of work with a series of in-depth assessments of selected critical work elements of the WBS prior to and following the project's PDR/NAR preceding KDP C. (Note: The CADRe is updated to reflect changes.)
    - Uses the latest available full-cost accounting initiative guidance and practices.
    - Includes reserves, along with the level of confidence estimate provided by the reserves based on a cost-risk analysis
    - Is time-phased by Government Fiscal Year (GFY) to WBS Level 2.

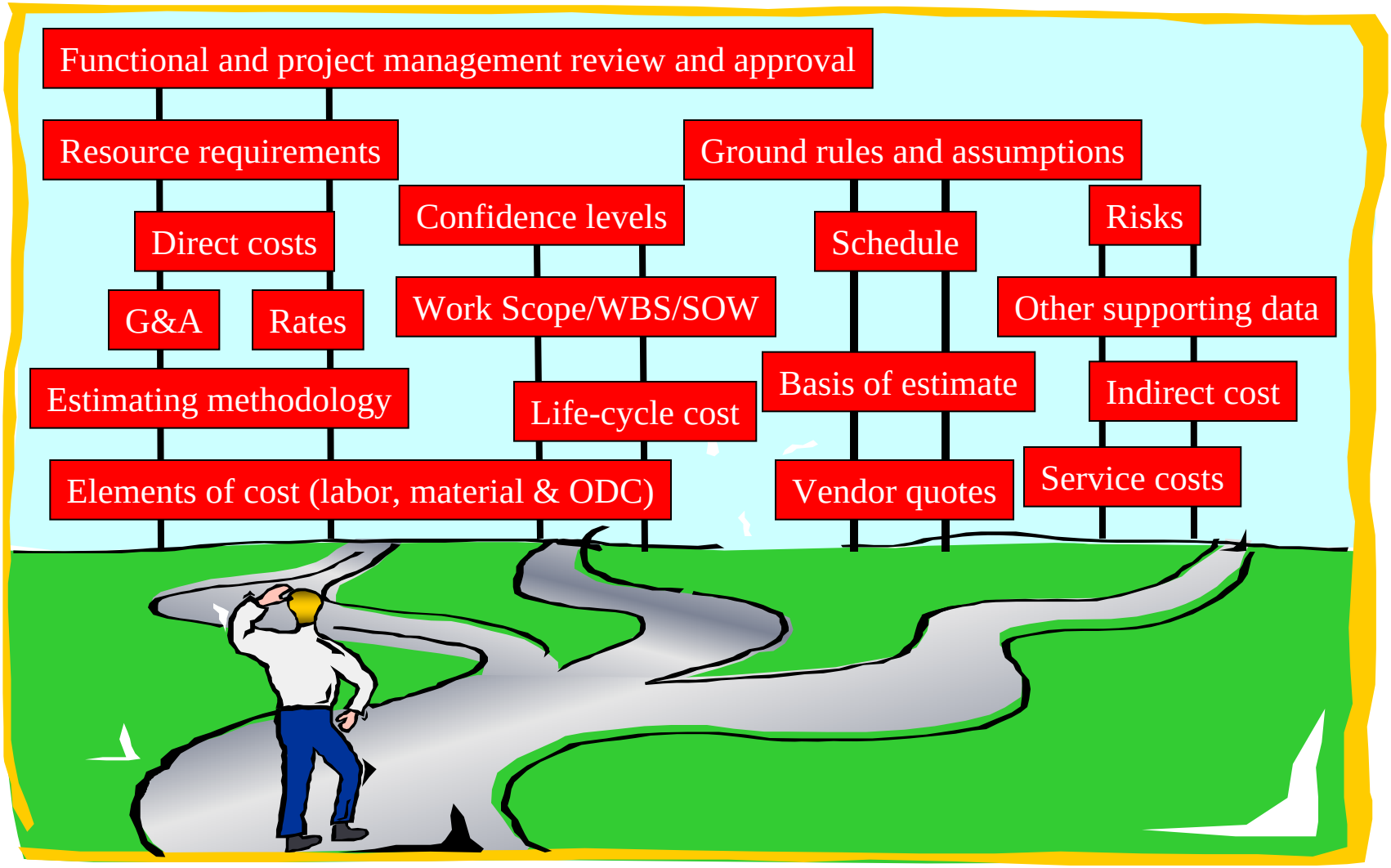
Source: NPR 7120.5D

Cost Analysis Data Requirements (CADRe)

- Cost Analysis Data Requirement (CADRe)
  - A formal document designed to help managers to understand the cost and cost risk of space flight projects. The CADRe consists of a Part A "Narrative," a Part B "Technical Data" in tabular form, both provided by the program/project to the ICE team. A "Project Life Cycle Cost Estimate," produced by the project team, is appended as Part C, but the ICE team does not see Part C until it has produced its own independent estimate.

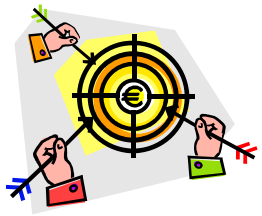
Source: NPR 7120.5D

Cost Estimate Considerations

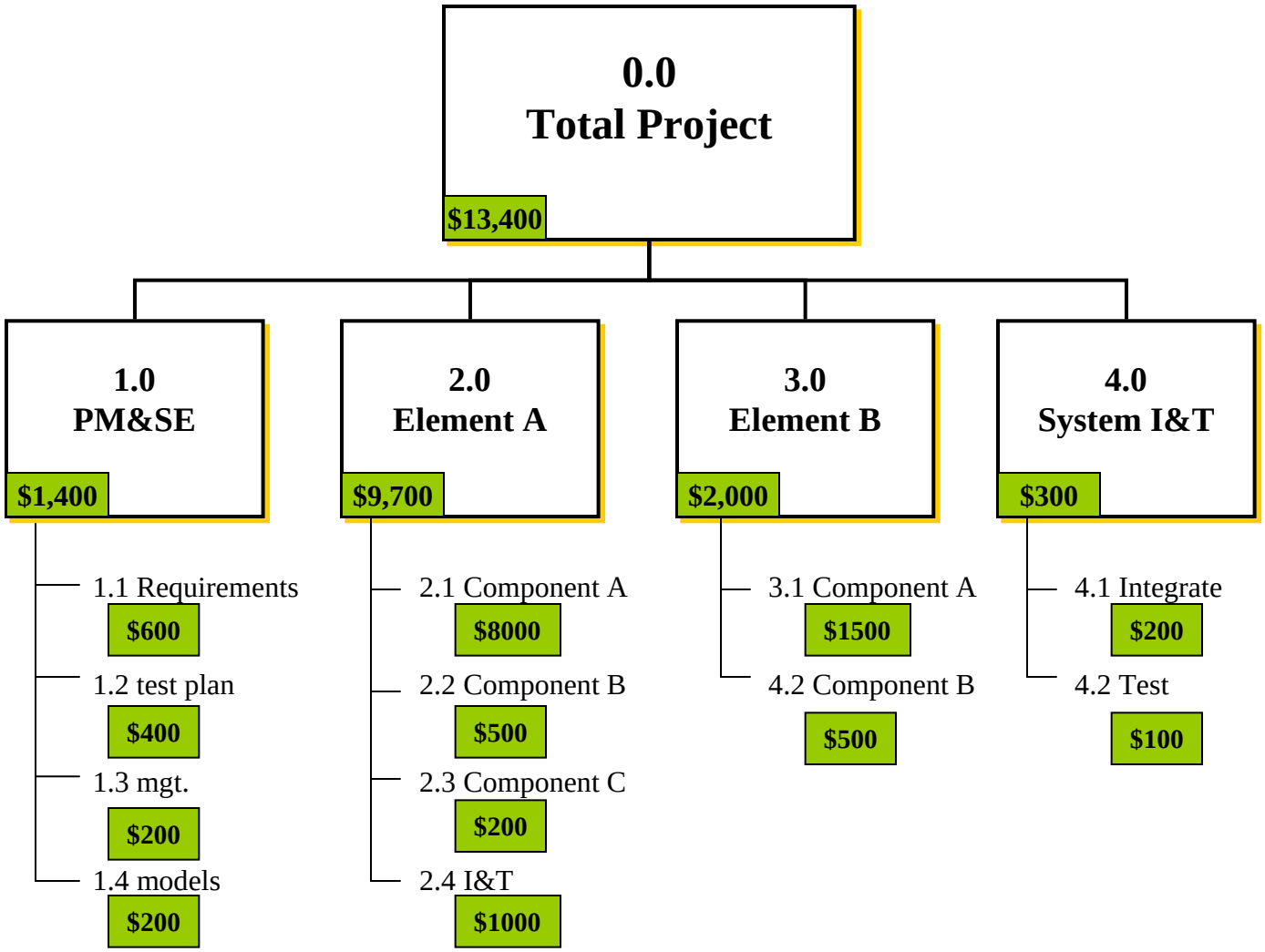


Estimating Methods

- **Parametric -** depends on cost history and an estimate of similarity between that project history available to the model and the project being estimated
- **Bottoms up -** an independent estimate by the project team of activities in the WBS
- **Top down -** reflect a value based on experience, marketing information, benchmarking data, and consulting information
- **Analogy -** similar to a top down estimate except that there is usually a cost history a the WBS level
- **Engineering/Expert Judgment -** Best guess of quantity of resources needed to perform the work scope based on prior, direct experience with similar effort

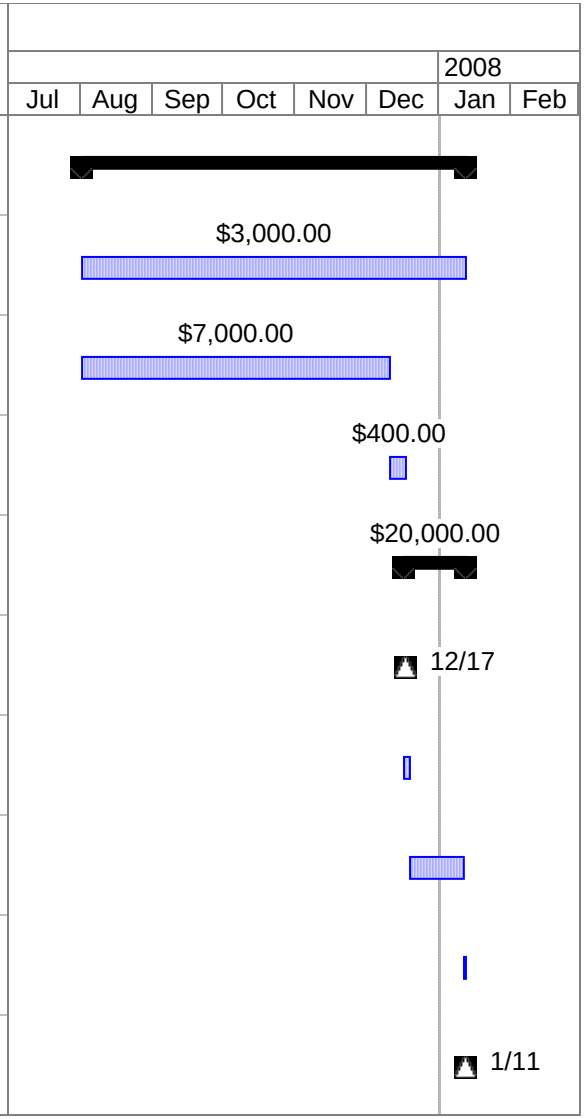


Project Budget



Cost and Schedule

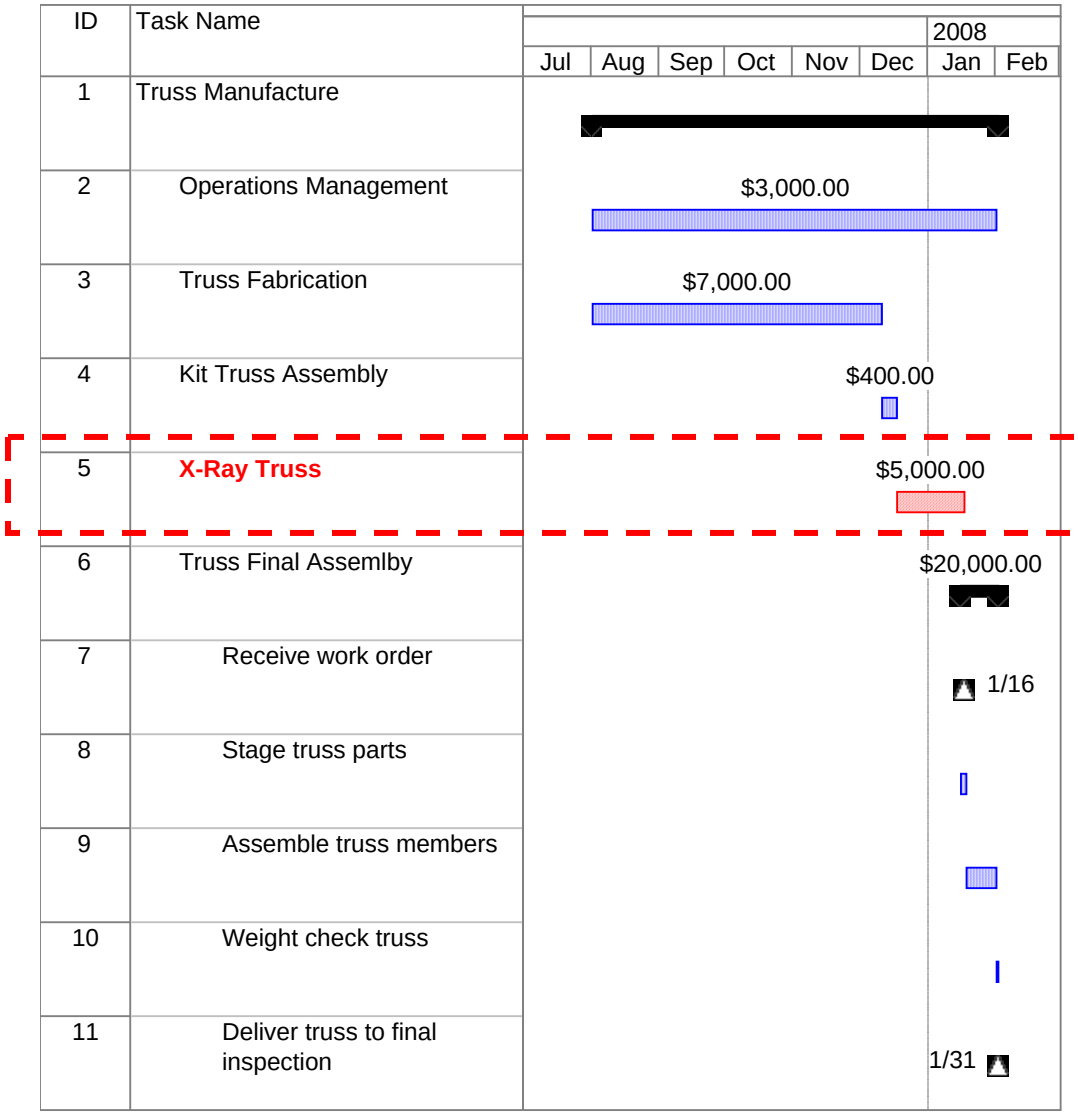
ID	Task Name
1	Truss Manufacture
2	Operations Management
3	Truss Fabrication
4	Kit Truss Assembly
5	Truss Final Assemlby
6	Receive work order
7	Stage truss parts
8	Assemble truss members
9	Weight check truss
10	Deliver truss to final inspection



Cost Timephased

	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Total
Operations Management		550	450	500	550	450	500		3,000
Truss Fabrication		1,000	1,500	2,000	1,500	1,000			7,000
Kit Truss Assembly						400			400
Final Truss Assembly						15,000	5,000		20,000
Total		1,550	1,950	2,500	2,050	16,850	5,500		30,400

Impact of Change



The CCB approves, and the project manager authorizes, a change adding the "X-Ray Truss" Work Package to the "Truss Manufacture" Control Account

Impact of Change on Cost Phasing

	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Total
Operations Management		550	450	500	550	450	500	3,000
Truss Fabrication		1,000	1,500	2,000	1,500	1,000		7,000
Kit Truss Assembly						400		400
X-Ray Truss						2,000	3,000	5,000
Final Truss Assembly							20,000	20,000
Total		1,550	1,950	2,500	2,050	3,850	23,500	35,400

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Confidence Level: NPD 1000.5 Section 1.g.4.a

- Programs are to be baselined or rebaselined and budgeted at a confidence level of 70 percent or the level approved by the decision authority of the responsible Agency-level management council.
- For a 70 percent confidence level, this is the point on the joint cost and schedule probability distribution where there is a 70 percent probability that the project will be completed at or lower than the estimated amount and at or before the projected schedule
- The basis for a confidence level less than 70 percent is to be formally documented

Source: NPD 1000.5

(See appendix for more information)

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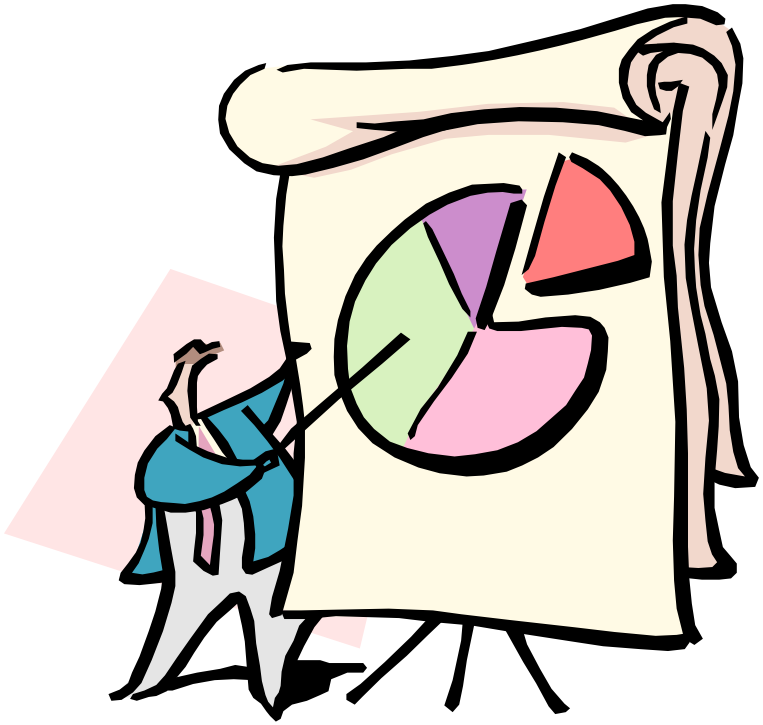
Cost Confidence



Cost

Risk

Analysis

Demo

Management Review and Approval

- A cost estimate is not the budget until it is reviewed and approved by the organization's functional and project management
- Work cannot begin without authorization
- What questions might management ask about your cost estimate?

Project Budgets

- Budget
  - An approved, authorized fiscal plan of operations for a given period
- Budgeting
  - Approving and allocating the cost estimates to the project activities
  - Authorizing the approved, time-phased cost estimate to the performing organization
  - Establishing the cost baseline for performance measurement

Budget vs. Funds

- Budget
  - More than an absolute number, must be timephased
  - A budget is only a plan
  - You cannot “spend” budget
- Funds
  - Dollars which you can actually spend
  - Provided to the project by the sponsor or customer

Types of Project Budgets

- Formulation
  - High level by major systems
  - Based on parametric, top down or similarity
  - No contractor historical performance financial information available
- Implementation
  - Detailed budget to subsystem or lower level
  - Based on grassroots data including staffing levels, rates, contracts
  - Historical performance plays a major role- schedule slips, overruns and technical problems help project future cost
- In-house
  - Particular attention must be paid to facility rates and policies since Civil Service labor makes up a large portion of the budget
  - Support service contract labor may consist of many different contracts
  - Very detailed budget to keep track of all of the sources of labor and materials
- Out of house
  - Focus on major contract requirements
  - Contractor historical performance and change control are key drivers
  - Type of contract/risk profile impacts reserve levels
  - Integration is more complicated

Estimate to Complete

- Periodically, you will assess how much it will cost to complete the work remaining on your task or project. This is called the “Estimate to Complete (ETC)”
- When added to the actual cost incurred so far, the resulting amount is called the “Estimate at Completion (EAC)”

EAC	=	Actual cost so far	+	Estimate to complete remaining effort

Analysis Clarifies Budget Requirements

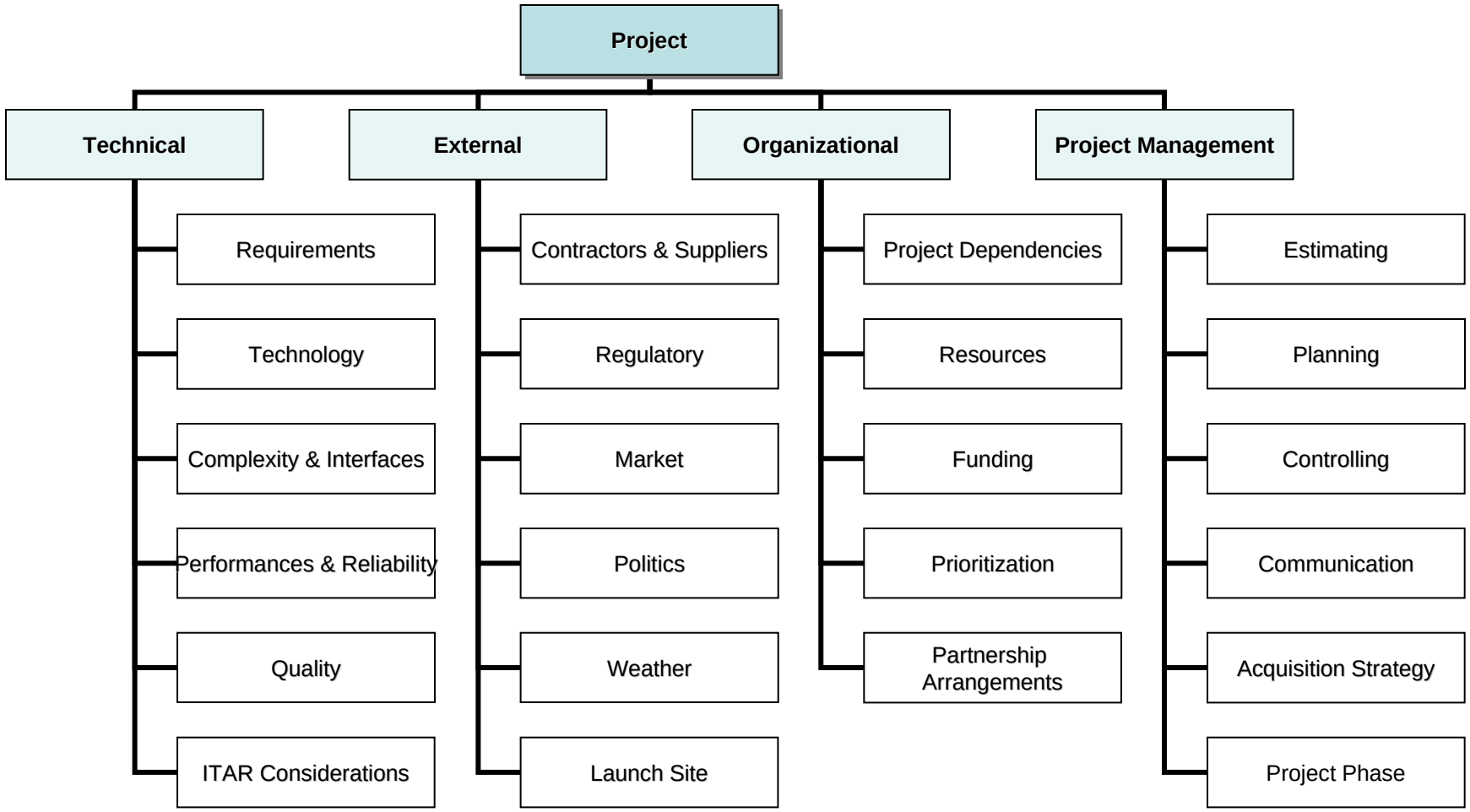
Examine Past Performance

- If EVM data is available, what are the performance trends?
- Has the cost to date been consistent with the cost plan?
- How does the technical percent complete of the project compare with the percent of funds spent?
- Is the project on schedule?
- Have required staffing skills and resources been available when needed?
- Has there been a large number of changes to the scope of the project?
- Have all changes been directed in writing rather than verbally?

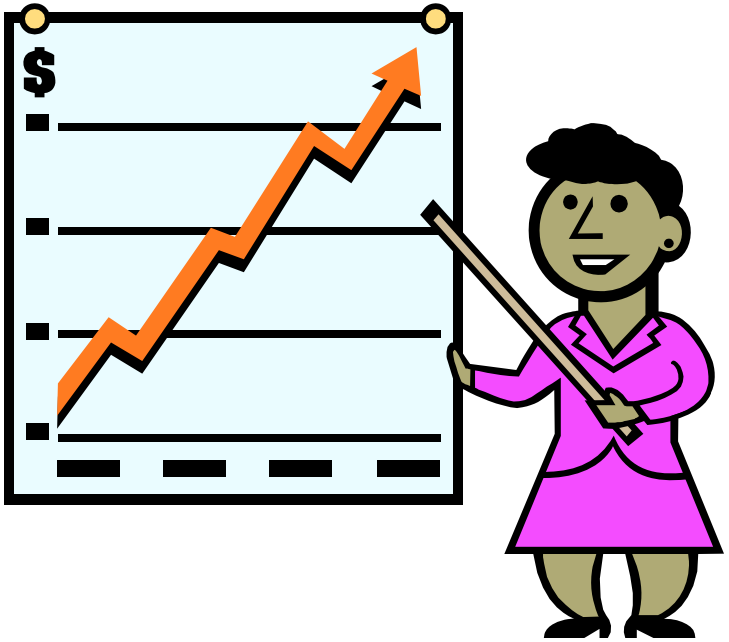
Forecast the Future

- Based on past experience, what adjustments should be made to the budget?
- Do configuration changes impact the schedule or cost?
- Are all risk factors identified and accounted for in the reserve strategy?
- Will the integration or delivery schedules change?
- Will staffing levels, skill mix or source change?
- Are anticipated contract scope changes covered?
- Have assumptions changed?

Risk Breakdown Structure



Earned Value Management

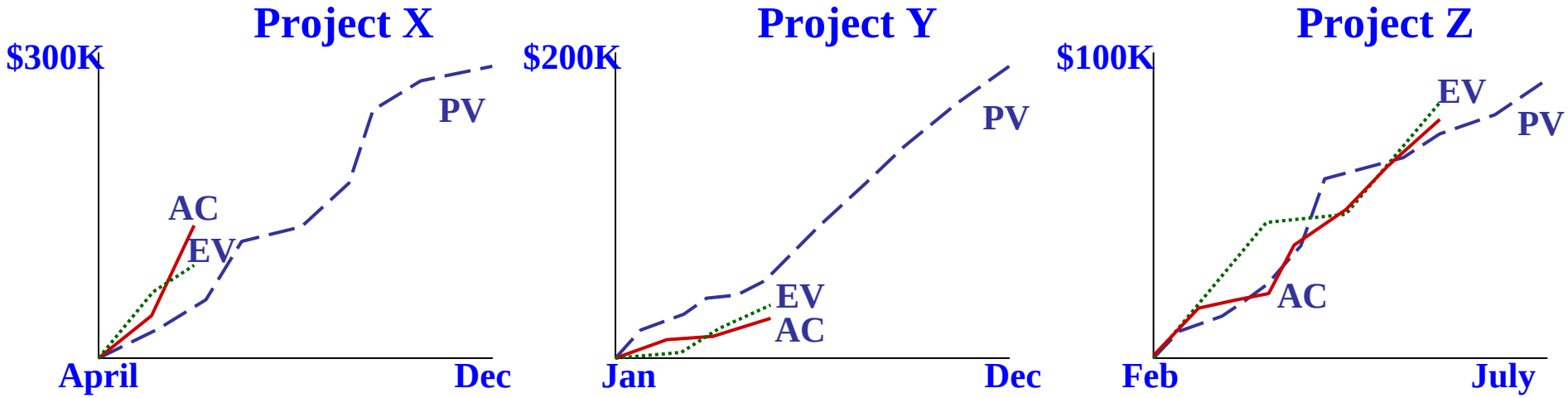


What is a baseline?

What is Earned Value Management?

Why do we have to measure performance and how do we do it?

Test Your EVM Knowledge!



1. Which projects are over running from a cost standpoint? (check all that apply)

- [ ] Project X
- [ ] Project Y
- [ ] Project Z

2. Which projects are ahead of schedule? (check all that apply)

- [ ] Project X
- [ ] Project Y
- [ ] Project Z

Key: **PV** - - - - - - **EV** ..... **AC** ———

Another Quiz

	Cost Performance	Schedule Performance
Project X:	CPI = 0.87	SPI = 1.1
Project Y:	CV = $70,125.23	SV = ($105,714.12)
Project Z:	EV = $1.15M, AC = $0.95M	Total Slack = 30 days

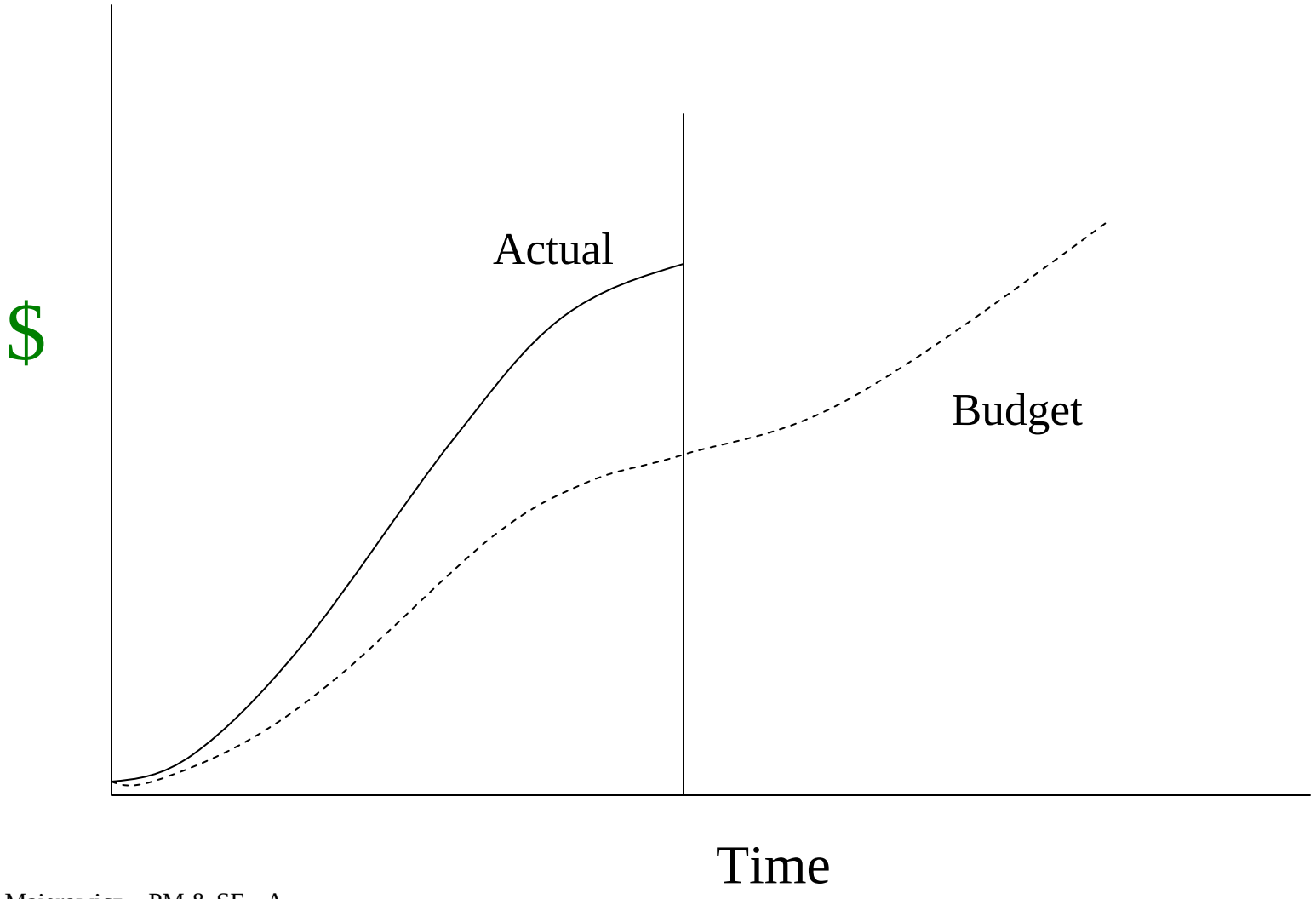
1. Which projects are under performing from a cost standpoint? (check all that apply)

[ ] Project X
[ ] Project Y
[ ] Project Z

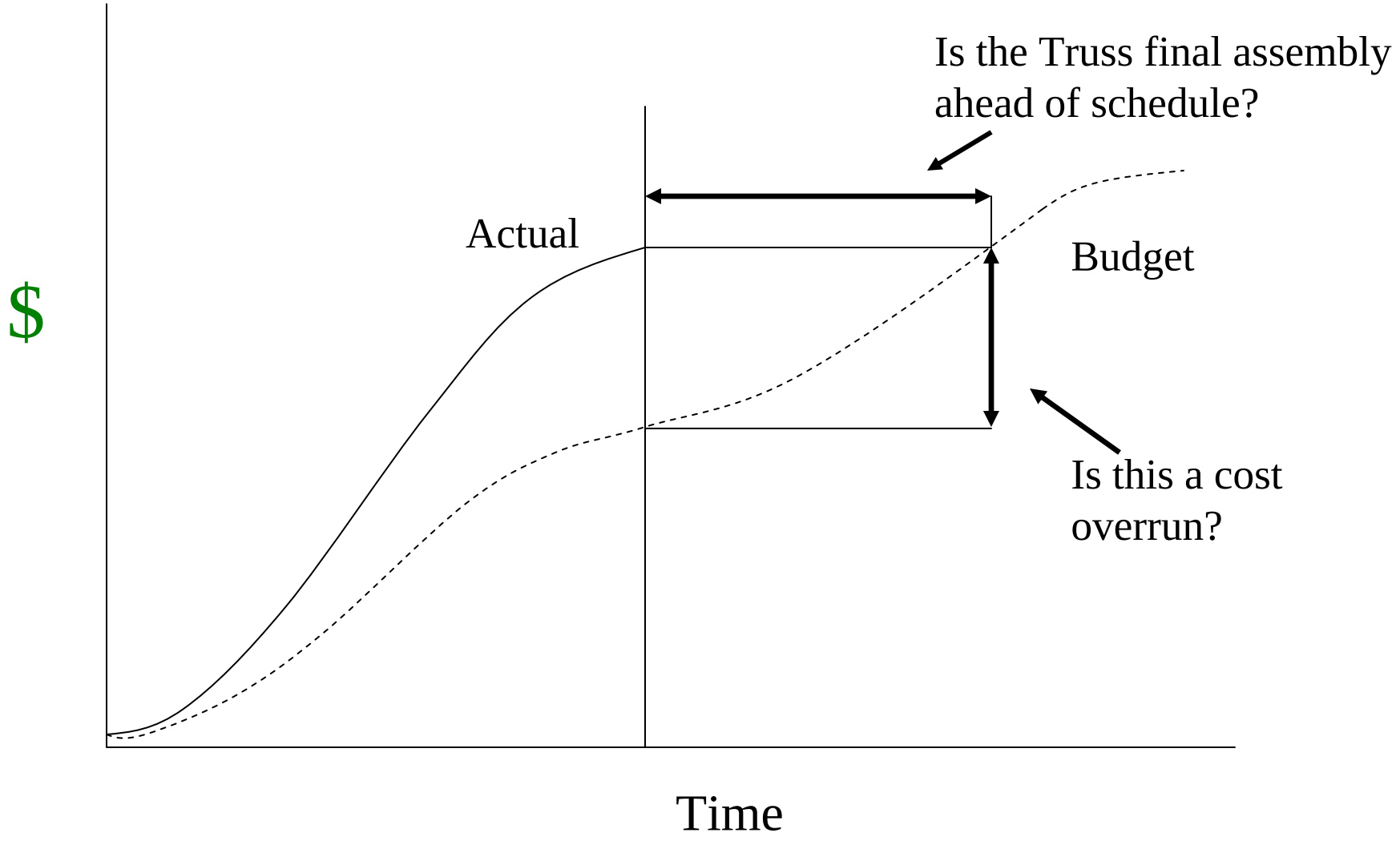
2. Which projects are ahead of schedule? (check all that apply)

[ ] Project X
[ ] Project Y
[ ] Project Z

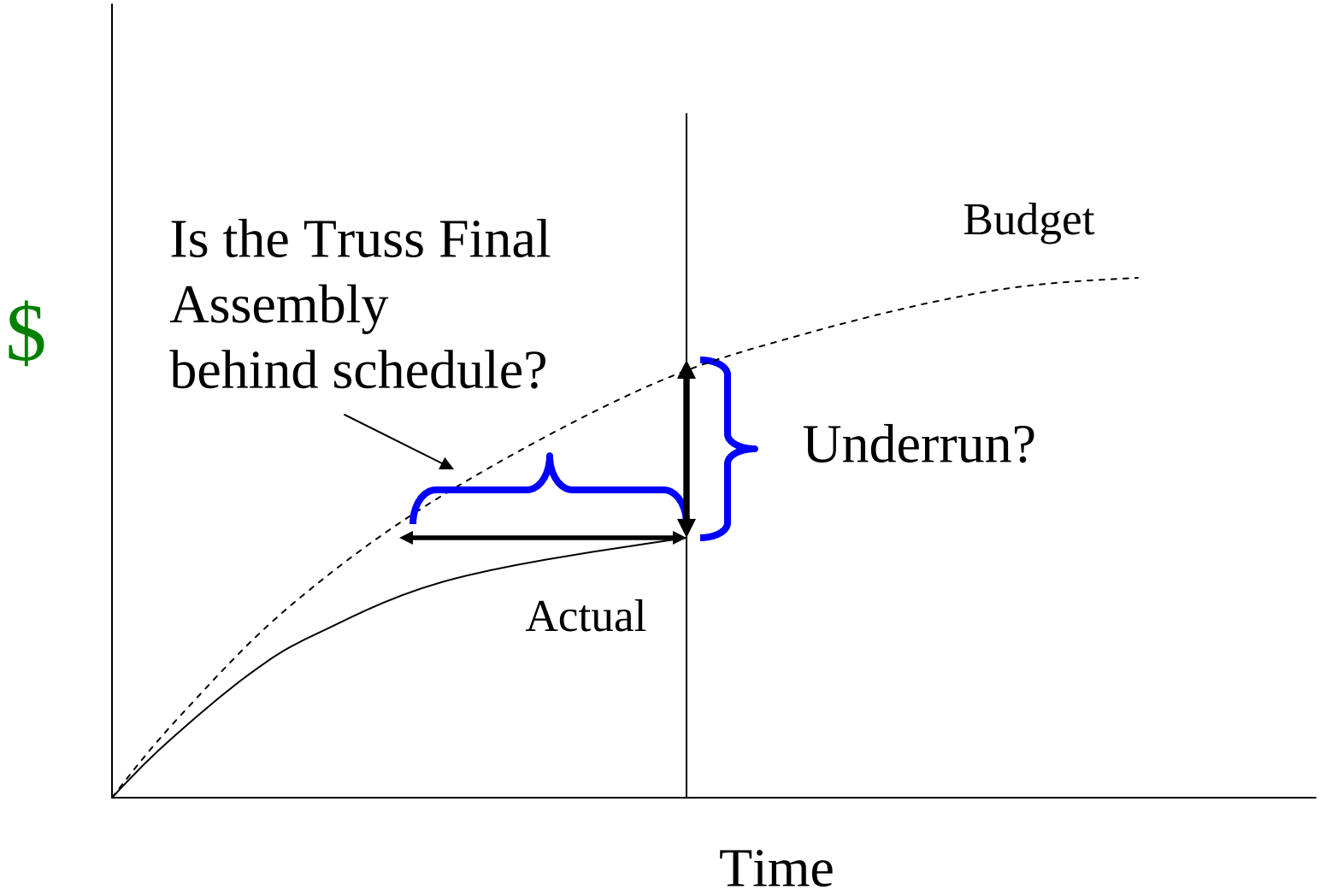
Comparison of Budget and Actual Cost



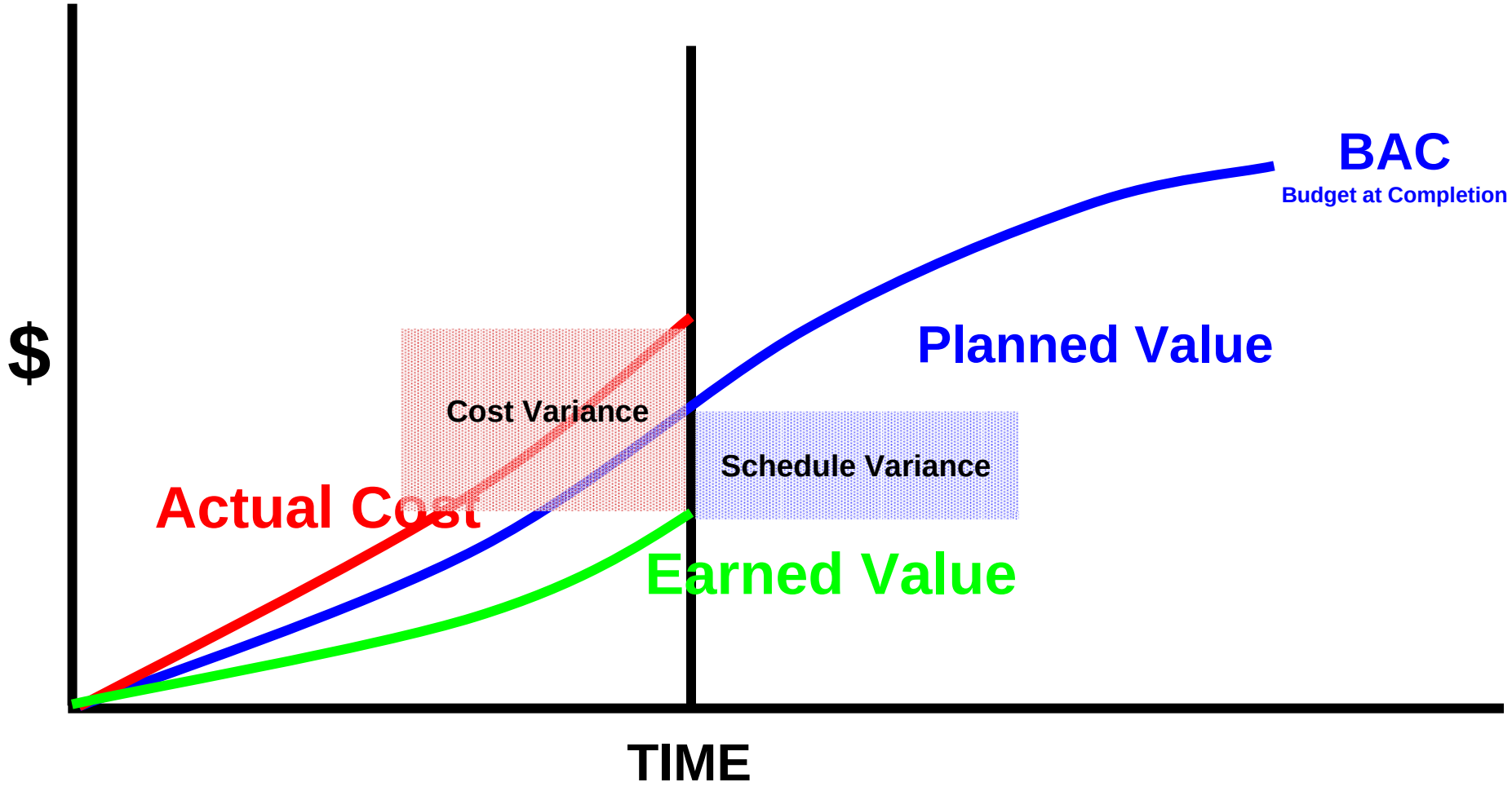
Truss Final Assembly Work Package



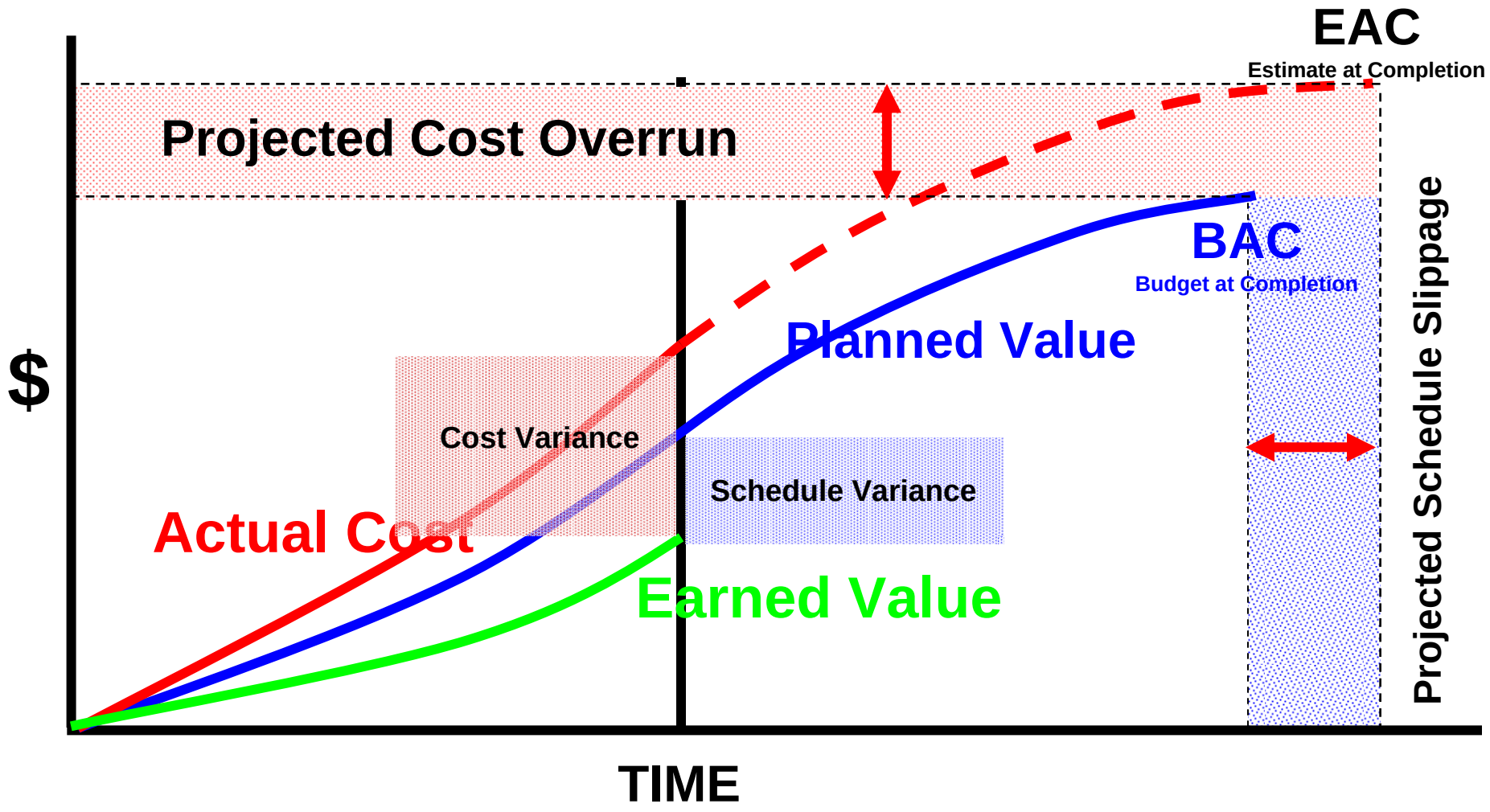
Truss Final Assembly Work Package



Performance Counts



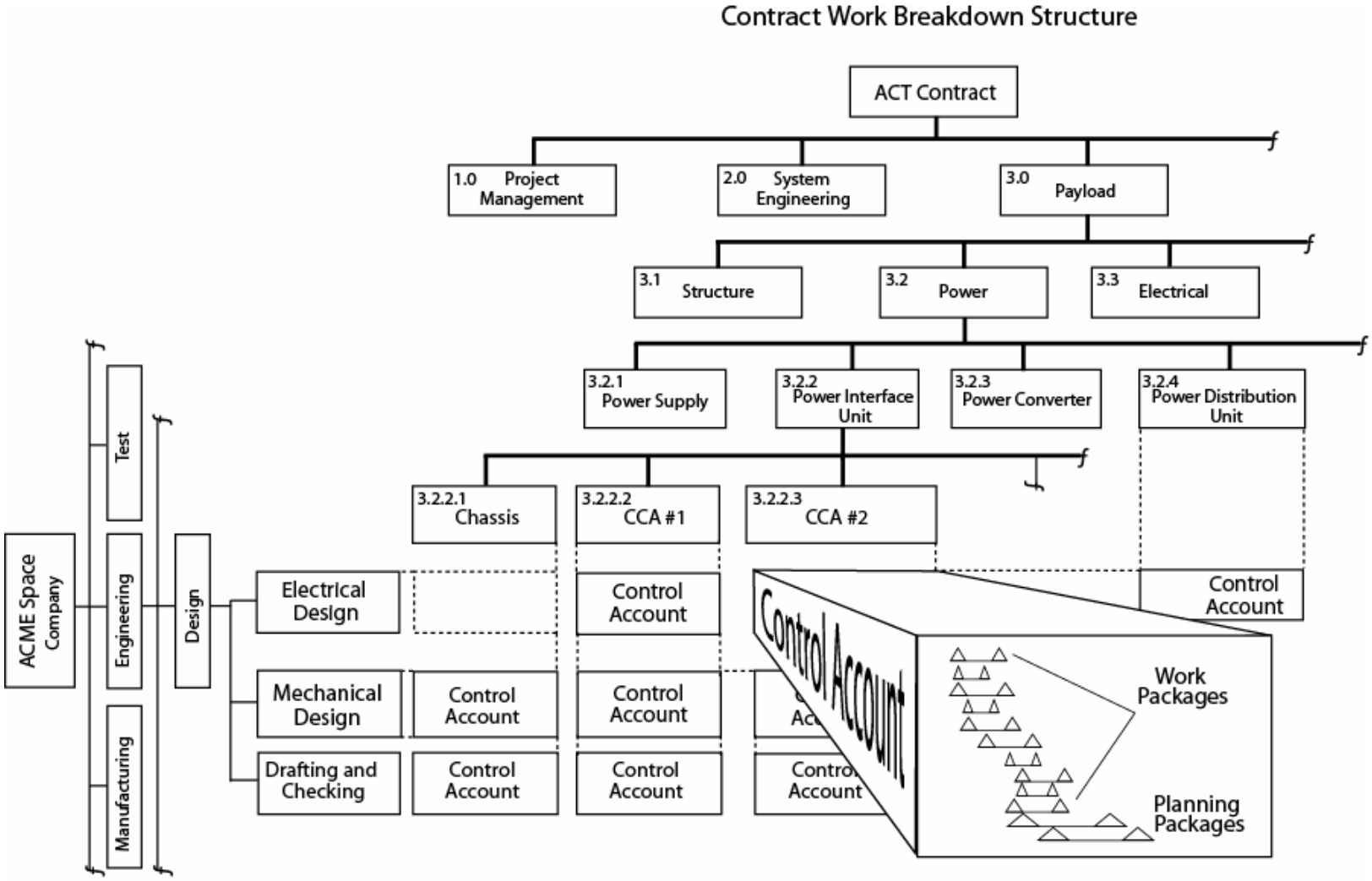
Early Warning



Primary Steps in Earned Value Management

- Plan all project work
  - Create an integrated performance measurement baseline
- Objectively assess work progress at the level of performance
  - Compare to the plan and to actual costs
- Analyze significant deviations from the plan
- Forecast impacts to cost and schedule
- Take corrective actions as needed
- Summarize data for progressively higher levels of management
- Maintain performance management baseline
  - Update for contract changes (work scope)
  - Maintain realistic baseline for remaining work

Responsibility Assignment Matrix

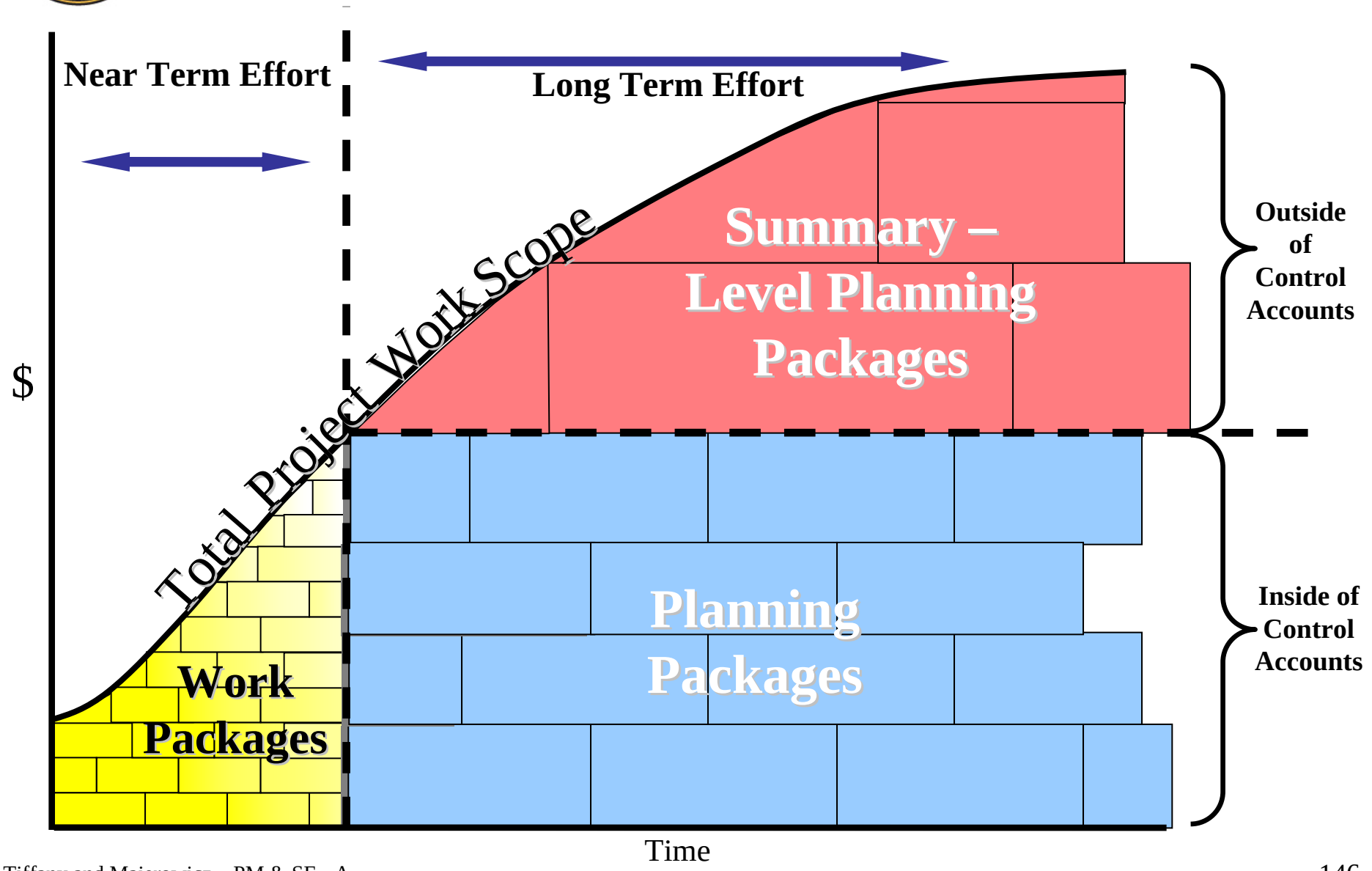


FY08 Orion ITA RAM - draft

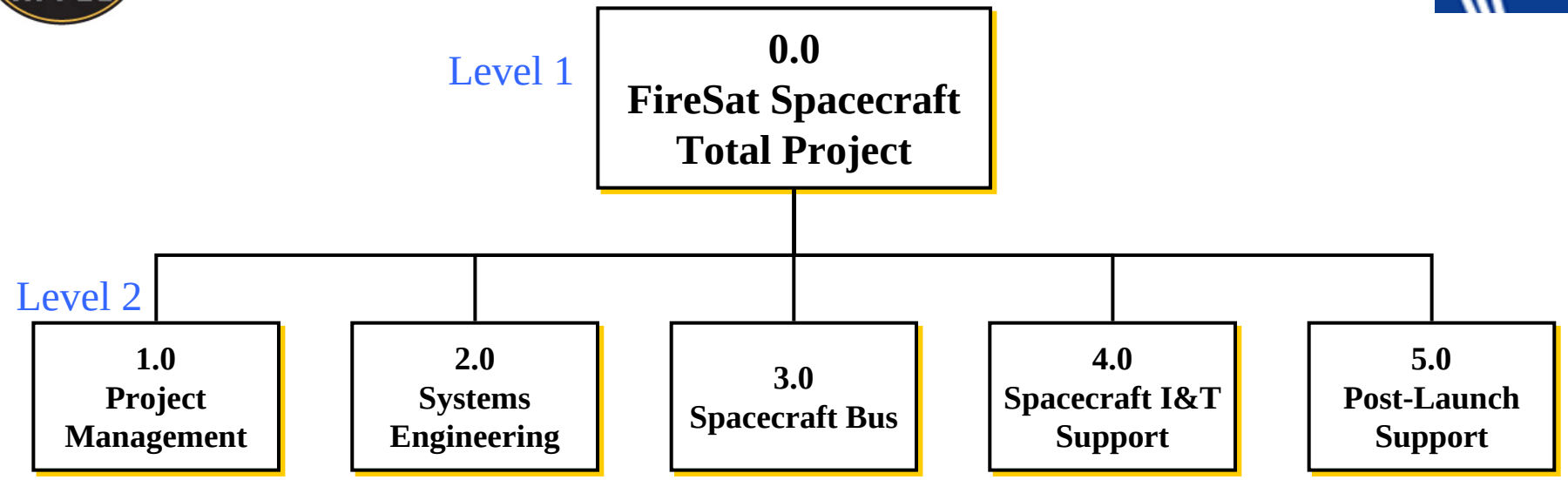
WBS Level 4	WBS Title	Gregory Stover	Irene Piatek	Jim Free	John Curry	John K. Trainor	Michael See	Robert E Floyd	FY08 Est $M
644423.01.31	CEV Mgmt and Administration							11.74	11.74
644423.01.32	Business Mgmt							4.38	4.38
644423.01.33	CM/DM							0.06	0.06
644423.01.35	Information Technology Mgmt							0.25	0.25
644423.01.37	Integrated Schedule Mgmt							0.16	0.16
644423.01.38	RESERVED for Special Studies							0.39	0.39
644423.02.31	VI Mgmt and Administration				0.38				0.38
644423.02.32	CEV Req's Definition and Mgmt				0.14				0.14
644423.02.33	CEV and Prog Integ & Interfaces				1.61				1.61
644423.02.34	Integrated Analysis				1.36				1.36
644423.02.35	CM Crew Cab & Cockpit LO Des Req				4.79				4.79
644423.02.36	CEV Systems Int Mgmt				24.31				24.31
644423.02.37	Flight and Ground Ops Int				2.52				2.52
644423.02.38	Specialty Engineering				8.13				8.13
644423.02.39	Aerosciences				24.54				24.54
644423.03.31	SR&QA Mgmt and Administration					1.09			1.09
644423.03.32	System Safety					2.56			2.56
644423.03.33	I/E/P Site, Launch Site & R Safe					3.53			3.53
644423.03.34	Reli, Maintain, & Support-RMS					2.42			2.42
644423.03.35	Hardware Quality Assurance					1.87			1.87
644423.03.36	Software Safety and Assurance					0.63			0.63
644423.04.31	Landing Attenuation Systems ADP		13.81						13.81
644423.06.31	Crew Module		61.96						61.96
644423.06.32	Service Module			13.42					13.42
644423.06.34	Launch Abort System	13.20							13.20
644423.06.35	CEV Software				10.90				10.90
644423.10.31	Test and Verification Mgmt & Adm						0.26		0.26
644423.10.33	Integrated Test and Verification						2.62		2.62
644423.10.34	Facilities						23.06		23.06
644423.10.36	Flight Test						53.79		53.79
644423.10.37	Special Studies/Projects-T&V						0.13		0.13
Grand Total		**13.20**	**75.76**	**13.42**	**78.69**	**12.10**	**79.86**	**16.98**	**290.01**

Still waiting on the ZV budget, LM's RAM, final ITA dollars and the technical leads that will be named as CAMs

Rolling Wave Planning



FireSat Project



Level 3 - 3.1 Structures

Level 4 - 3.1.1 Primary Structure
- 3.1.2 Secondary Structure

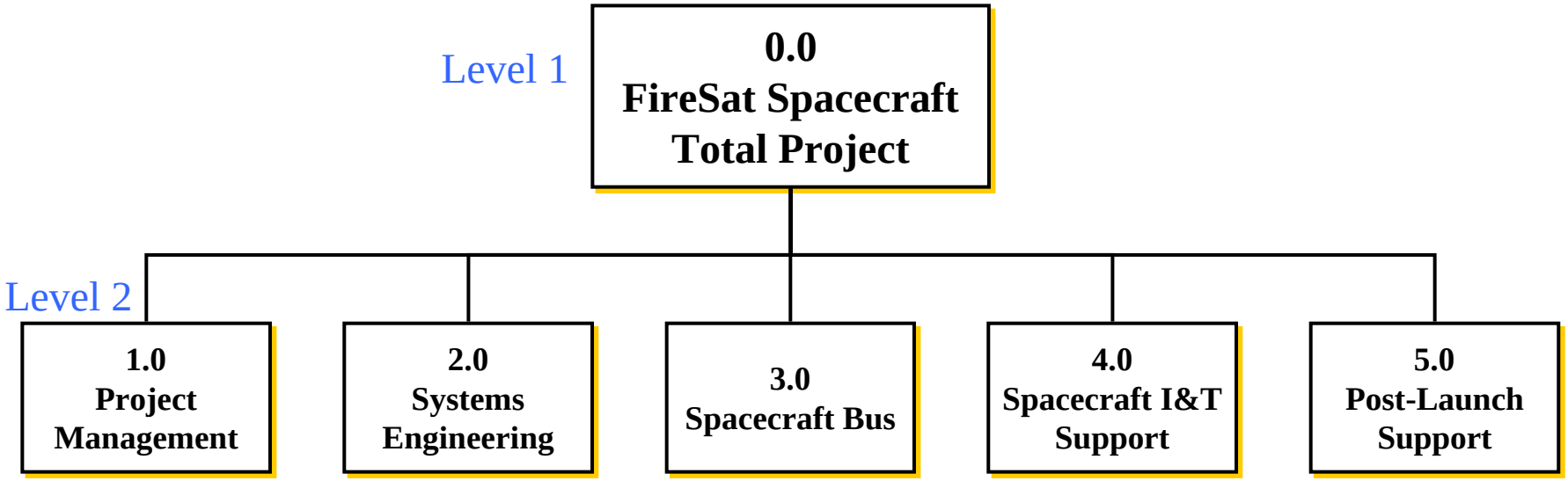
Level 5 - 3.1.2.1 Truss

Control Account: Truss Manufacture

Work Packages:
Operations Management
Truss Fabrication
Kit Truss Assembly
Truss Final Assembly

Activities: In Integrated Master Schedule / logic network

FireSat Budget



Level 3	- 3.1 Structures	
Level 4	- 3.1.1 Primary Structure - 3.1.2 Secondary Structure	
Level 5	- 3.1.2.1 Truss	
Control Account	Truss Manufacture	**$30,400**
Work Packages	Operations Management	**$3,000**
	Truss Fabrication	**$7,000**
	Kit Truss Assembly	**$400**
	Truss Final Assembly	**$20,000**
Activities	In Integrated Master Schedule / logic network	

Earned Value Measurement Methods

Abbreviation	Name	Approach	Application
LOE	Level of Effort	• Earned value always equal to planned value	• Work of a supporting nature, impractical to plan, not directly related to a definable end product
Milestone	Weighted/ Incremental Milestone	• Work package budget is divided among milestones based on their weighted values • No partial credit	• An event which identifies significant, measurable and verifiable progress • Best when work packages exceed two months
0/100; 50/50	Fixed Formula	• Work is distributed so that it adds up to 100% • % value is "earned" based on defined start and completion dates	• Best used for detailed work packages of very short duration
% Complete	Percent Complete	• Earned value is a subjective assessment of what percentage of the total effort is completed.	• Useful on work packages of 3 months or more where it is not practical to identify milestones for measuring progress
Milestone Gates	Percent Complete Estimate with Milestone Gates	• % complete earned value estimate up to milestone "gate"	• Incorporates the objectivity of milestones as performance gates with the subjectivity of percent complete assessment
Units Complete	Units Complete	• Specifying the budgeted value per unit of output and applying it to the planned output quantity • Earned value = actual quantity of output completed x budgeted rate per unit	• Used on effort where status is taken by counting output
Apportioned Effort	Apportioned Effort	• Earned value of the apportioned task always reflects same percentage earned value of the discrete base task	• Work has a direct supporting performance relationship to other discrete work known as the "measurement base"

Example Control Account Plan
FireSat Truss Manufacture

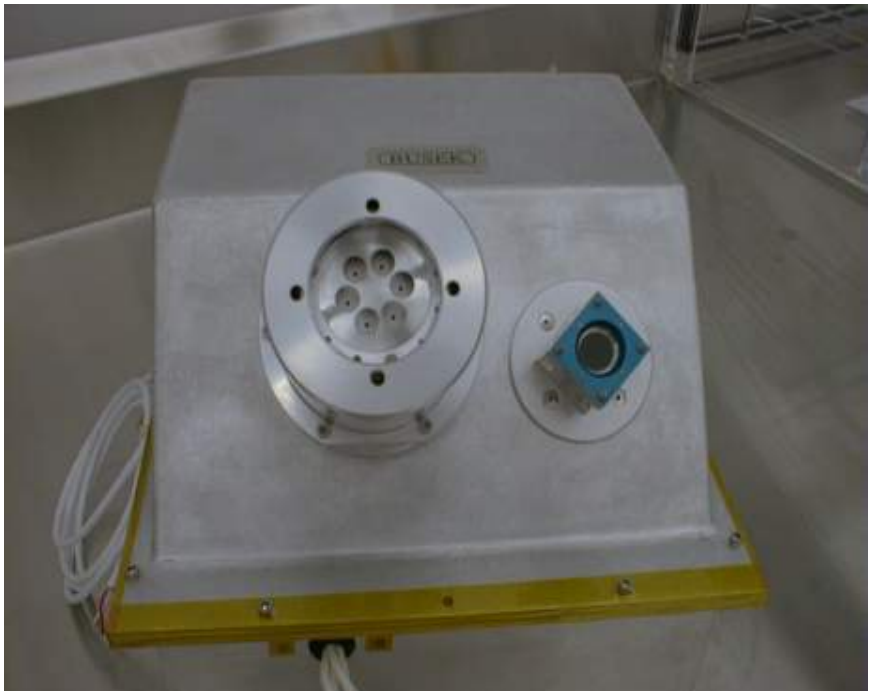
WBS 3.1.2.1 Truss								Revision: Baseline	
Control Account Plan: Truss Manufacture					Org Code: 750 Operations			CAM: B. Emmett	
Work Package	EV Method		Aug	Sep	Oct	Nov	Dec	Jan	BAC
Operations Mgt.	LOE	PV EV AC	△ 500	500	500	500	500	500 △	3000
Truss Fabrication	Percent Complete Estimate	PV EV AC	△ 1500	1500	1500	1500	△ 1000		7000
Kit Truss Assembly	0/100 Fixed Formula	PV EV AC					△ 400 △		400
Truss Final Assembly	Percent Complete/ Milestone Gates	PV EV AC					10000	10000	20000
Total CAP		PV EV AC	2000	2000	2000	2000	11900	10500	30400

FireSat
Group Exercise

Taking Earned Value

FireSat Thruster Mechanical Design

- It’s now the end of December, and time to take Earned Value for the Thruster mechanical design effort your team has been working
- Let’s take a look at the Control Account Plan



Determine December Earned Value

WBS 3.6.1									Revision: Baseline
Control Account Plan: Thruster Mechanical Design			Org Code: 760 Mechanical Engineering					CAM: R. Smith	
Work Package	EV Method		Oct	Nov	Dec	Jan	Feb	Mar	**DEC CUM**
Engineering Management	LOE	PV EV AC	500 500	500 500	500	500	500	500	1500
Drawing Release	Percent Complete Estimate	PV EV AC	5000 5000	5000 2500	5000	2500	2500		15000
Structural Analysis Report	50/50 Fixed Formula	PV EV AC	200	200 0	200				400
Material Trade Study	Weighted Milestones	PV EV AC			1000	1000	1000	2000	1000
Total CAP		PV EV AC	5500 5700	5700 3000	6700	4000	4000	2500	17900

FireSat Thruster Mechanical Design

- Based on the following information, record the December and cumulative Earned Value for the Thruster Control Account:
  - Ron Smith, the Control Account Manager, was on vacation for half of December, so he only charged the "Engineering Management" Work Package 50% of what he normally does
  - The "Drawing Release" Work Package is estimated to be 75% complete
  - Tina, who is in charge of the "Structural Analysis" Work Package said she will not be finished her first report until January 15th, instead of December 15th as originally planned, however she estimates she is 90% done in December
  - Joe, the "Material Trade Study" Work Package Manager successfully completed both his December and January milestones, and estimates he is 75% finished the February milestone

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FireSat Thruster Mechanical Design
Earned Value through December

WBS 3.6.1									Revision: Baseline
Control Account Plan: Thruster Mechanical Design			Org Code: 760 Mechanical Engineering					CAM: R. Smith	
Work Package	EV Method		Oct	Nov	Dec	Jan	Feb	Mar	**DEC CUM**
Engineering Management	LOE	PV	500	500	500	500	500	500	1500
		EV	500	500	**500**				**1500**
		AC							
Drawing Release	Percent Complete Estimate	PV	5000	5000	5000	2500	2500		15000
		EV	5000	2500	**7500**				**15000**
		AC							
Structural Analysis Report	50/50 Fixed Formula	PV		200	200				400
		EV	200	0	**0**				**200**
		AC							
Material Trade Study	Weighted Milestones	PV			1000	1000	1000	2000	1000
		EV			**2000**				**2000**
		AC							
Total CAP		PV	5500	5700	6700	4000	4000	2500	17900
		EV	5700	3000	**10000**				**18700**
		AC							

Planned Value (PV)
Building Batteries

Month 1
PV = $1,000K

Month 2
PV = $1,000K

Month 3
PV = $1,000K

Month 4
PV = $1,000K

Month 5
PV = $1,000K

Total Budget = $5,000K
to be spent over 5 months.
I plan to build 1 battery
each month at an
estimated cost of $1,000K per
battery.
PV each month = $1,000K

Each dollar of planned value represents a specific dollar of work scope

Cumulative Planned Value (PV)

Month 1
PV = $1,000K

Month 2
PV = $1,000K

Month 3
PV = $1,000K

Month 4
PV = $1,000K

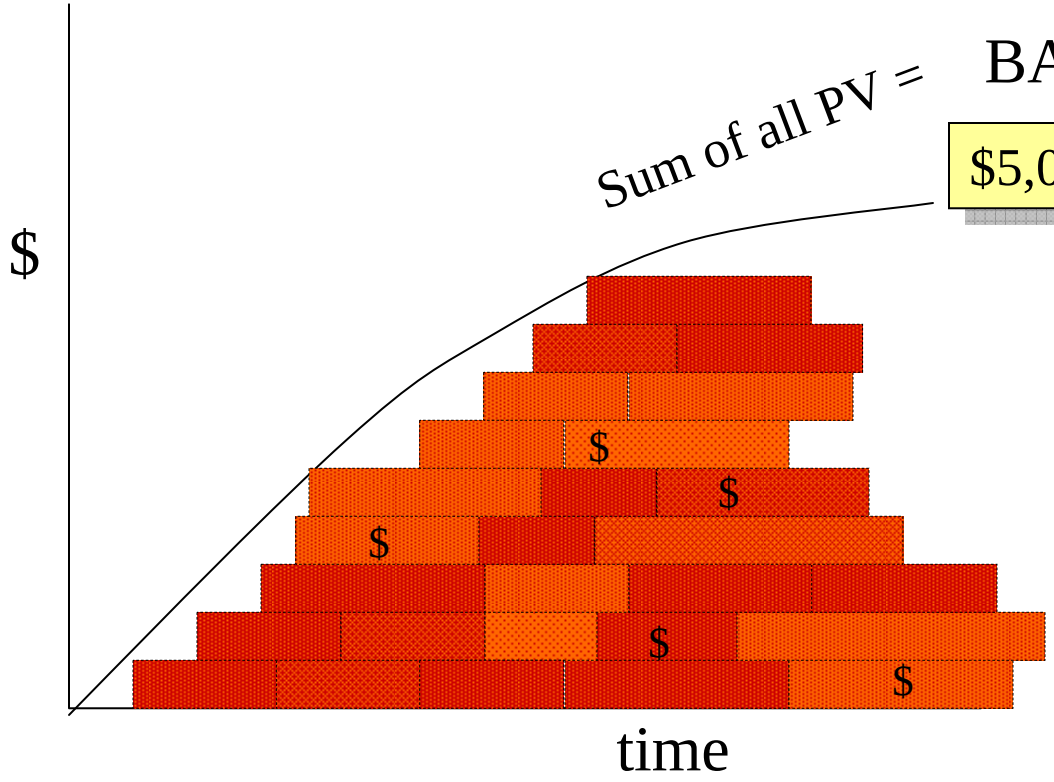
Month 5
PV = $1,000K

Total Budget = $5,000K

Total PV = $5,000K

PV is aggregated and summed as the performance measurement baseline

Budget at Completion (BAC)



The baseline is composed of many lower level work packages. These sum up to the total value of the project or contract.

Earned Value (EV)

We're at the end of the second month, but only 1 battery is complete. Earned value of work completed = $1,000K

"Earned Value" is simply taking credit for the portion of the budget associated with the quantity of work actually performed

Schedule Variance

PV – of the work I planned to have done, how much did I budget for it to cost?

EV – of the work I actually performed, how much did I budget for it to cost?

SCHEDULE VARIANCE is the difference between work planned and work performed (expressed in terms of budget dollars)

formula: **SV $ = EV- PV**

example: SV = EV – PV = $1,000K - $2,000K
SV = -$1,000K (negative = behind schedule)

Schedule Performance Index (SPI)

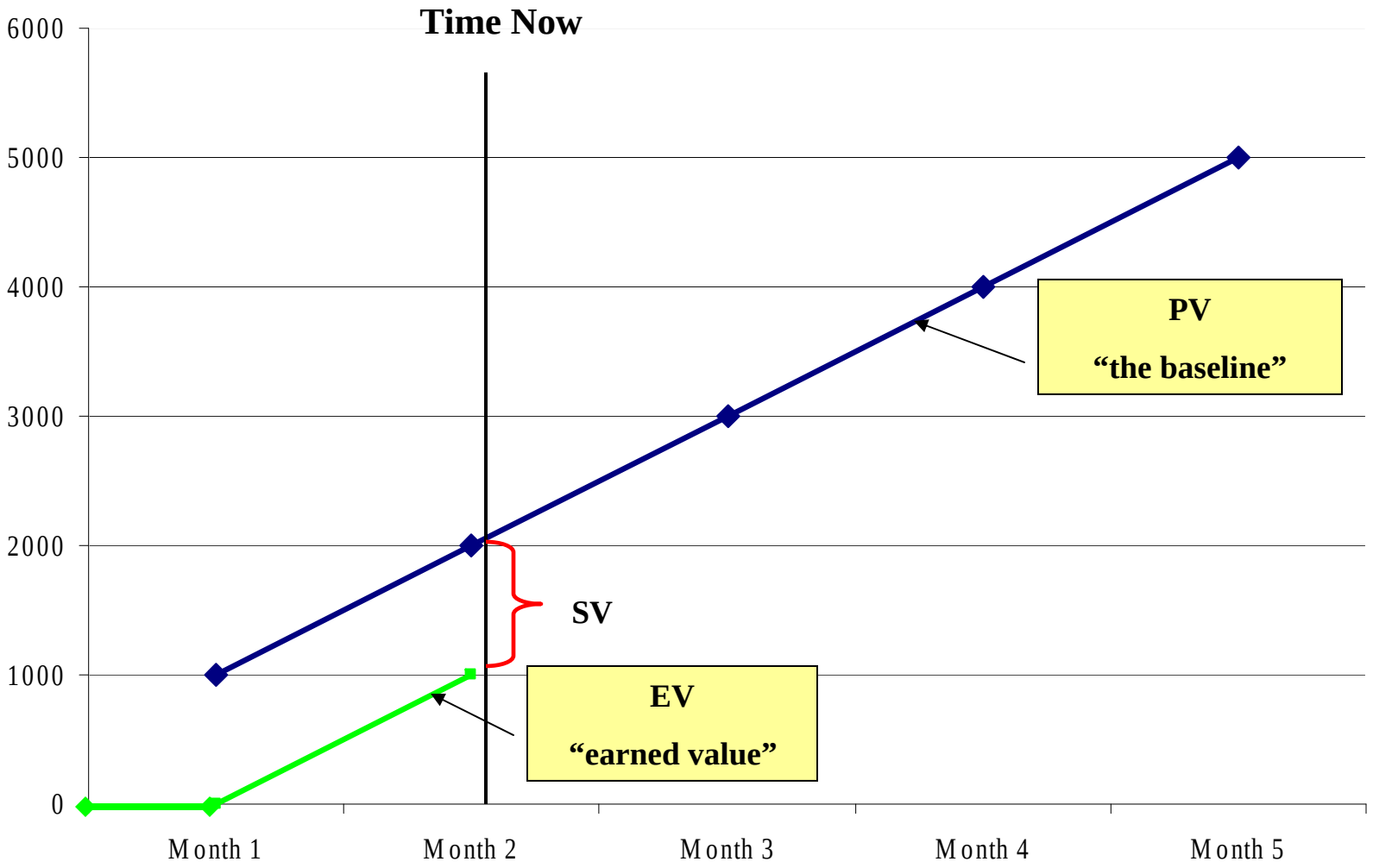
- More valuable early in contract life.
- Favorable SPIs > 1.0
- Unfavorable SPIs <1.0
- SPI equals 1.0 at end of contract

$$SPI = \frac{\text{Earned Value}}{\text{Planned Value}}$$

$$SPI = \frac{EV}{PV}$$

Given a SPI of 0.72, for every dollar of work scheduled for completion only 72 cents worth of work was completed.

Schedule Variance



Schedule Variance (recap)

- Schedule Variance = EV – PV
  - Difference between the amount of work accomplished and what the baseline said should have been accomplished.
  - $1,000 - $2,000 = -$1,000 (behind schedule)
- Percent Schedule Variance = SV / PV
  - -$1,000 / $2,000 = -50% (behind schedule)
- Schedule Performance Index (SPI) = EV / PV
  - Work Performed / Work Planned
  - $1,000 / $2,000 = 0.50
  - Schedule efficiency: for every dollar of work planned to be completed by this date, only 50 cents has actually been completed
- The Schedule Variance goes to zero at the completion of the project, so it is less relevant as an indicator of performance later in the project life.

Examples of Schedule Variance Causes

- Staffing Shortages
- Wrong skill mix
- Waiting for something or someone
- Late vendor delivery
- Scope creep
- Poor estimate/ initial schedule
- Unanticipated work complexity
- Technical Problem
- Process Problem
- Incorrect assumption
- Over optimistic schedule
- Unanticipated programmatic constraint
- Vague, incorrect, or ill-defined requirements

(Analysis will also include assessment of impact and corrective actions.)

Actual Cost (AC)

Labor came to $1,300K,
and materials cost $1,100K.
We've spent $2,400K to date.

Value of AC comes from actual accounting records

Cost Variance

EV – of the work I actually performed, how much did I budget for it to cost?

AC – of the work I actually performed, how much did it actually cost?

COST VARIANCE is the difference between earned value and actual cost

formula: **CV $ = EV- AC**

example: CV = EV – AC = $1,000K - $2,400K
CV = -$1,400K (negative = cost overrun)

Cost Performance Index (CPI)

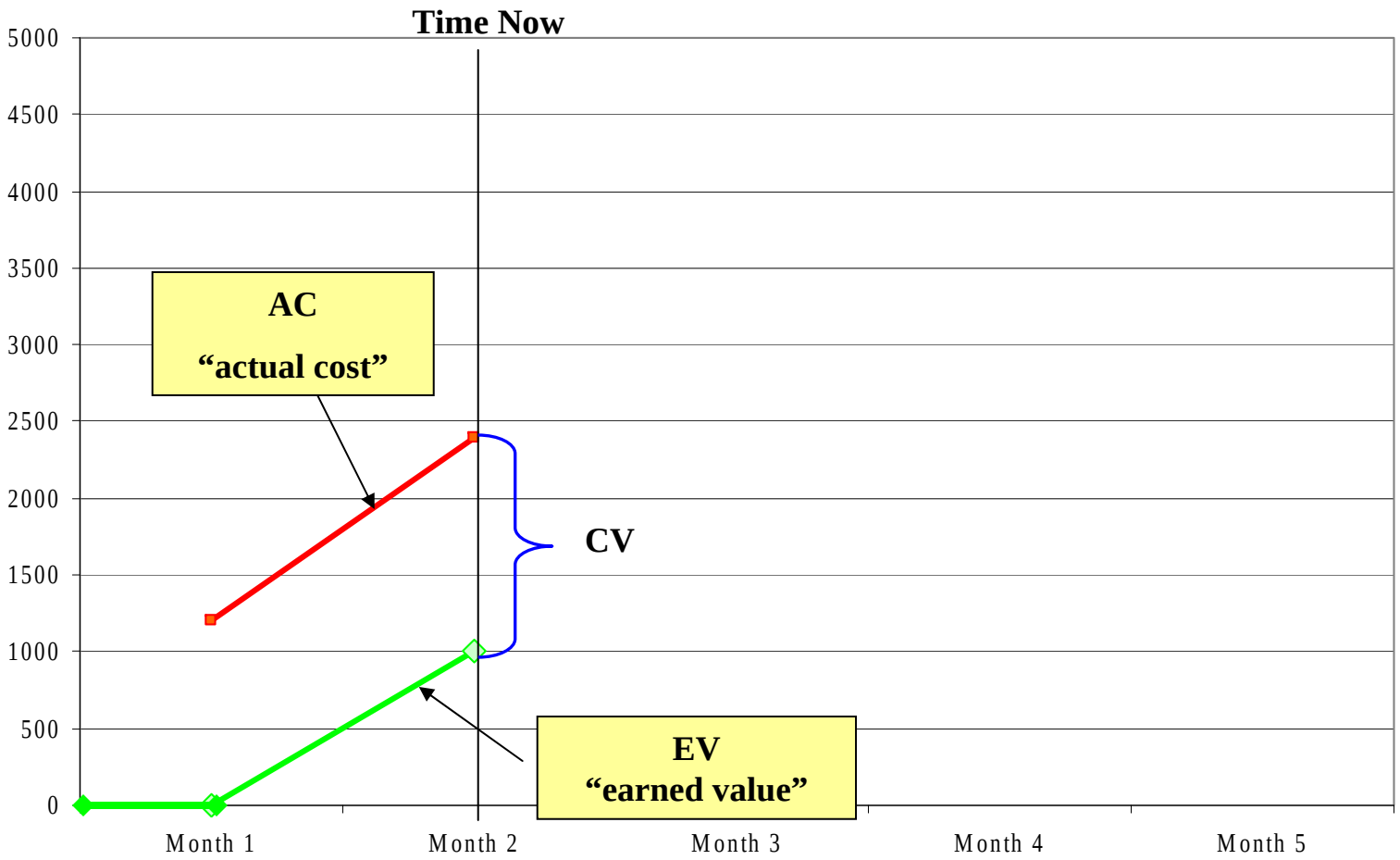
- More valuable than SPI metric for computing EAC
- Favorable CPIs > 1.0
- Unfavorable CPIs <1.0

$$CPI = \frac{\text{Earned Value}}{\text{Actual cost}}$$

$$CPI = \frac{EV}{AC}$$

Given a CPI of 0.65, for every dollar spent 65 cents of work or earned value was realized.

Cost Variance



Cost Variances (recap)

- Cost Variance = EV – AC
  - Difference between the cost of work accomplished and what the baseline said that work should have cost
  - $1,000 - $2,400 = -$1,400 (cost overrun)
- Percent Cost Variance = CV / EV
  - -$1,400 / $1,000 = -140% (cost overrun)
- Cost Performance Index (CPI) = EV / AC
  - Work Performed / Actual Costs
  - $1,000 / $2,400 = 0.41
  - Cost efficiency: for every dollar spent, only 41 cents of work has been completed

Examples of Cost Variance Causes

- Many of the same causes of schedule variances along with
  - Staff inefficiency
  - Rate increases
  - Material price escalation
  - Poor estimate / baseline was insufficient
  - “Gold Plating”
  - Unit rate/usage differences

(Analysis will also include assessment of impact and corrective actions.)

EV Thresholds

EV Threshold	SPI Meaning	CPI Meaning	Management Strategy
>1.10	Well ahead of schedule	Well under Budget	Revalidate plan, scope & estimates. Be suspicious.
0.95 to 1.10	On schedule	On Budget	Monitor. Stay tuned to be on track.
0.90 to 0.95	Slightly behind Schedule	Slightly over Budget	Mitigate risks. Early warning alerts.
<0.90	Way behind schedule	Way over budget	Initiate corrective actions.

Source:
"Earned Value Business Solutions:
Implementation, Lessons-Learned and Best Practices," Mohan Kondur, PMP
The Measurable News, Summer 2007

Estimate at Completion (EAC)

They want to know the final cost! I guess it will be……$7500K.

I hope that's right.

EAC is the total of the actual cost to date and the estimate to complete the remaining work.

Variance at Completion (VAC)

BAC - what the **total** job is supposed to cost

EAC - what the **total** job is expected to cost

VARIANCE AT COMPLETION is the difference between what the total job is supposed to cost and what the total job is now expected to cost.

FORMULA: **VAC = BAC - EAC**

example: VAC = $5,000K - $7,500K
VAC = -$2,500K (negative = overrun)

To Complete Performance Index (TCPI)

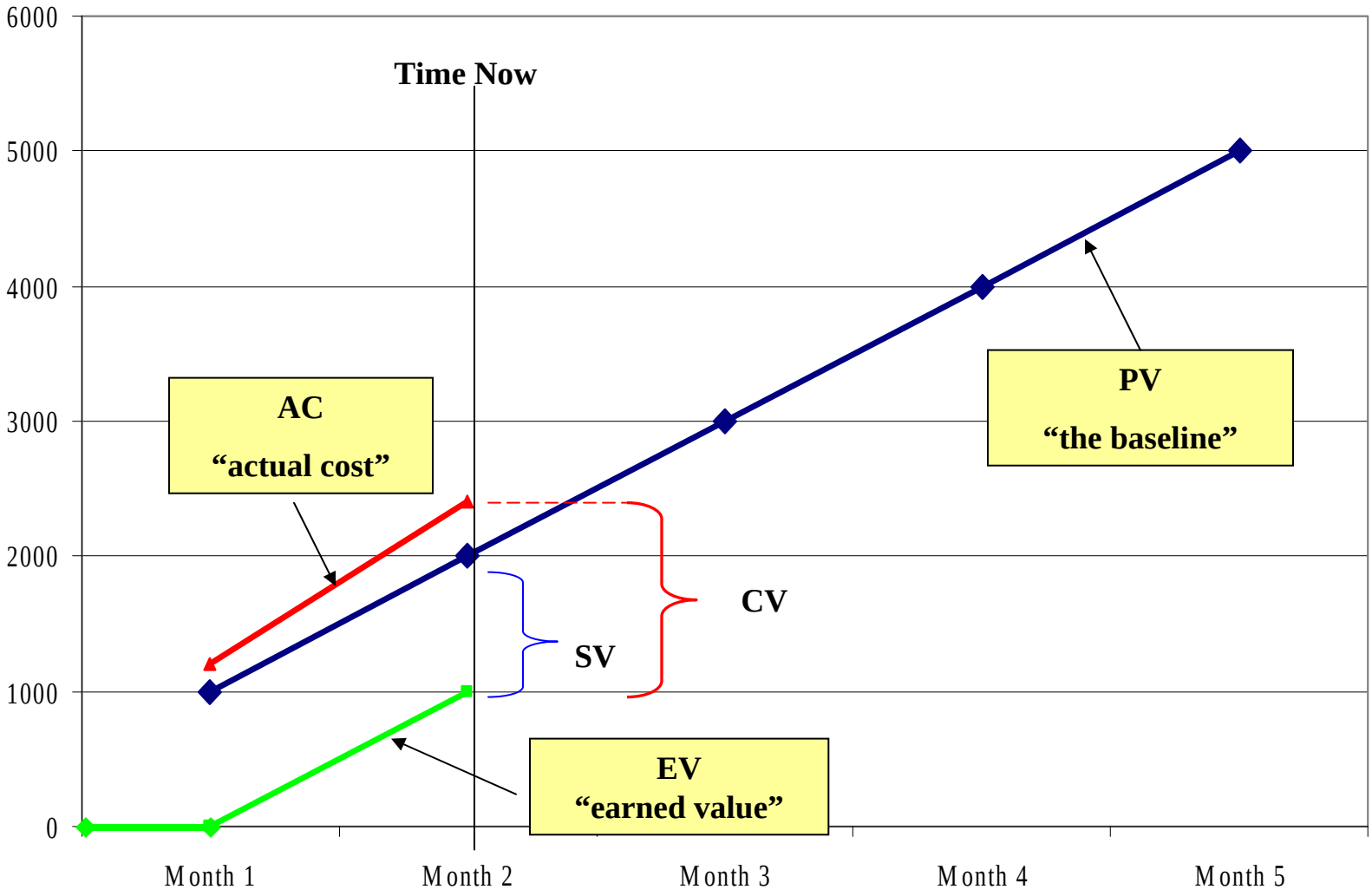
- Used to assess the reasonableness of the bottoms-up / grass roots EAC
- Identifies future cost efficiency required to achieve a target EAC

$$TCPI = \frac{\text{Work Remaining}}{\text{Estimate to Complete}}$$

$$TCPI = \frac{BAC - EV_{cum}}{EAC - AC_{cum}}$$

Given a TCPI of 1.20, for every dollar spent from here to the end of the contract, one dollar and 20 cents of work or earned value must be realized (To finish within the current EAC).

Performance Status



Variance Rules of Thumb

- Values can be expressed as either current period or cumulative
  - Current period is more volatile
  - Cumulative data to shows trends
- Interpretation:
  - Negative variances are bad
  - Positive variances are usually good
  - Index < 1.0 is bad
  - Index > 1.0 is good
- Absolute
  - Expressed in terms of dollars or hours (e.g., -$2,000)
  - Significance is hard to determine without additional information
- Percent
  - Relates absolute variance to a base (e.g., -35%)
  - Shows significance
- Index
  - Compares one value to another in a simple ratio
  - If the index equals 1.00, you are on plan

NPR 7120.5D – Excerpts from EVM Requirements

- EVM approach must be in place by the Key Decision Point (KDP) C and implemented in Phase C through KDP E
- EVM principles as defined by ANSI/EIA 748, apply from KDP C to KDP E if the project's life cycle cost is at or greater than $20M
- If the project's primary NASA Center has a fully validated EVMS, the project must use guidelines instead of principles
- Contracts over $20M must comply with ANSI/EIA 748 guidelines
- Contracts over $50M must be formally determined compliant with ANSI/EIA 748 by the cognizant contract management agency
- EVM is not required for grants, non-developmental level-of-effort engineering services, basic and applied research

NASA FAR Supplement

- Application of an Earned Value Management System (EVMS) is required for all acquisitions for development designated as major in accordance with OMB Circular A-11, and for development or production contracts and subcontracts, including those for flight and ground support requirements, and institutional requirements (facility, IT investment, etc.) as follows:
  - For contracts and subcontracts valued at $20M or more, and contracts and subcontracts for major acquisitions valued at less than $20M, the EVMS shall comply with the guidelines in the ANSI/EIA-748 Standard
  - For contracts and subcontracts valued at $50M or more, the contractor shall have an EVMS that has been formally validated and accepted by the Government
  - For contracts and subcontracts for other than major acquisitions valued at less than $20M, earned value management application is optional and is a risk-based decision that is at the discretion of the program/project manager

EIA 748 Principles

1. Plan all work scope for the project to completion
2. Break down the project work scope into finite pieces that can be assigned to a responsible individual or organization for control of technical, schedule and cost objectives
3. Integrate project work scope, schedule and cost objectives into a performance measurement baseline plan against which accomplishments may be measured
* 4. Control changes to the performance measurement baseline
5. Use actual costs incurred and recorded in accomplishing the work performed
6. Objectively assess accomplishments at the work performance level
7. Analyze significant variances from the plan, forecast impacts, and prepare an estimate at completion based on performance to date and work to be performed
8. Use the EVMS information in the management processes

* shown as a separate principle for this course

SOURCE: EIA-748-B / EIA Standard Earned Value Management Systems

EIA-748-B Guidelines

CATEGORY	NUMBER OF GUIDELINES	HIGHLIGHTS
Organization	5	Define the authorized work and assign responsibility for work. Integrate planning, scheduling, work authorization, and cost accumulation processes.
Planning, Scheduling & Budgeting	11	Plan, schedule, budget and authorize work. Establish and maintain a time-phased budget baseline. Identify and control LOE. Identify MR and UB.
Accounting Considerations	6	Record direct costs consistent with budget. Record material cost in period EV is measured.
Analysis and Management Reports	5	Compare PV, EV and AC, and analyze variances. Implement managerial actions taken. Horizontal and vertical communications and traceability. Develop revised estimates of cost at completion.
Revisions & Data Maintenance	5	Timely incorporation of contractual changes. Maintain traceability from original budgets. Prohibit retroactive changes. Document changes to PMB.

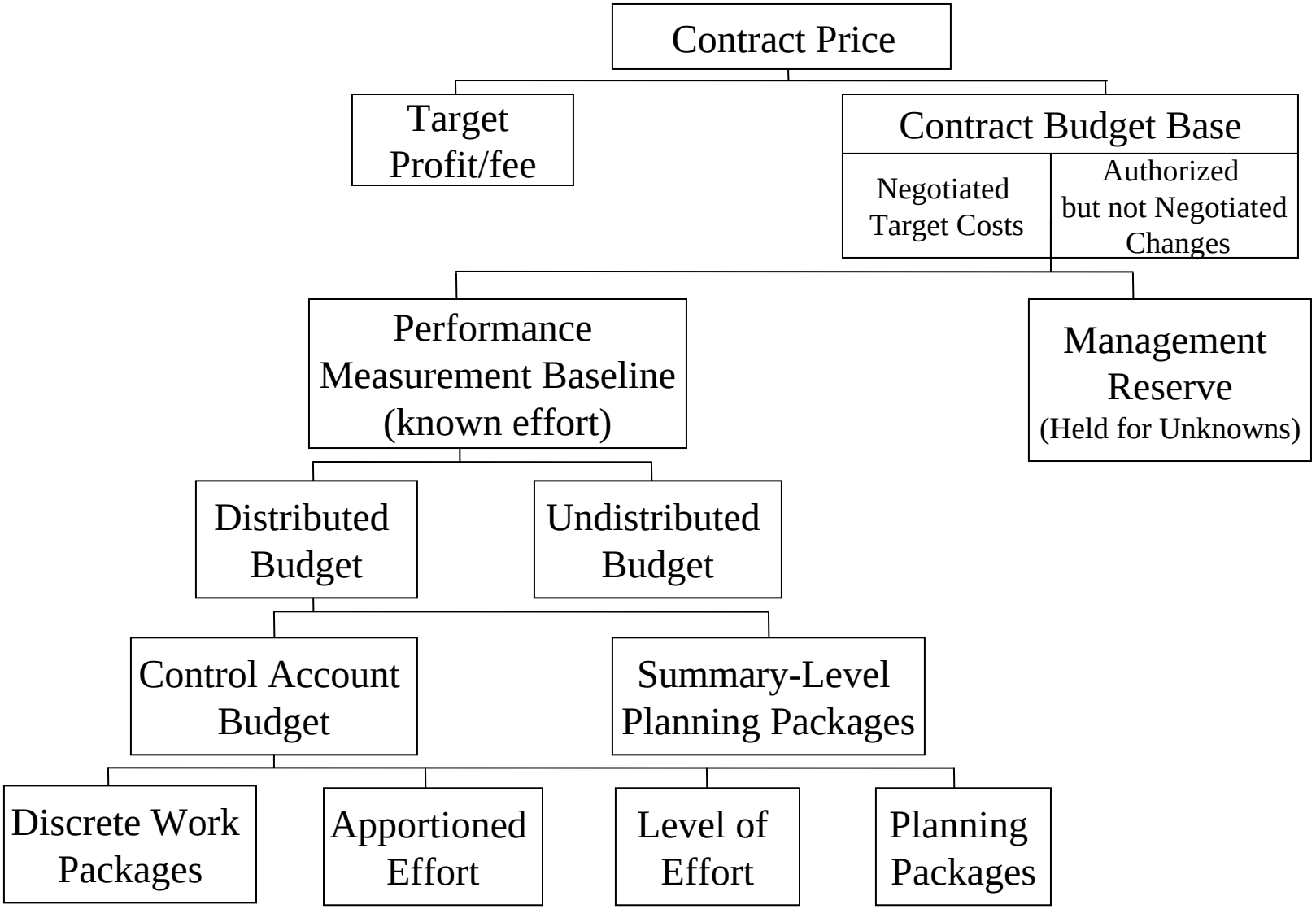
DOD EVM Experience on Over 700 Projects

- When a project is as early as 15% complete, the cumulative cost performance efficiency stabilizes, providing a basis for predicting the final project (or contract) cost
  - Overrun at completion will never be less than the overrun to date
  - Percent overrun at completion will be no less than the current percent overrun, and probably greater
  - The remaining or “to go” cost performance efficiency will not likely change by more than +/- 10% by the time the project (or contract) finishes.

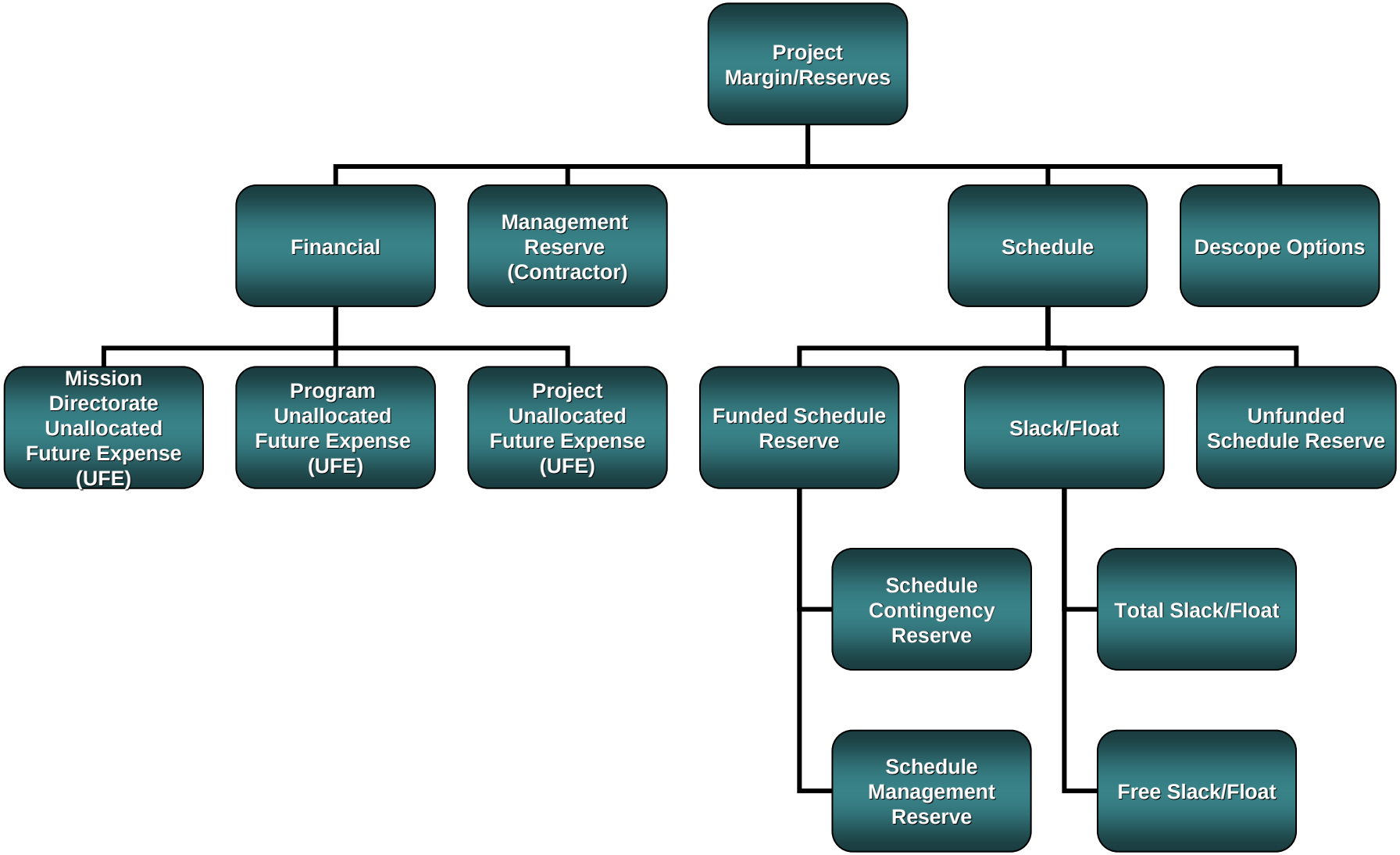
Key EVM Terms

- **PV**- Planned Value (BCWS) ***SHOULD DO***
- **EV** – Earned Value (BCWP) ***DID DO***
- **AC** – Actual Cost (ACWP) ***WHAT IT COST***
- **BAC** – Budget at Completion (Total Work)
- **EAC** – Estimate at Completion (Total Funds)
- **ETC** – Estimate to Complete = EAC – AC
- **CV** – Cost Variance = EV-AC
- **SV** – Schedule Variance = EV-PV
- **CPI** – Cost Performance Index = EV/AC
- **SPI** – Schedule Performance Index = EV/PV
- **BCWR** - Budgeted Cost of Work Remaining = BAC - EV
- **TCPI –** To Complete Performance Index = BCWR/ETC
- **% Complete** = EV/BAC
- **% Spent** = AC/EAC (or AC/BAC)
- **% Complete Planned** = PV/BAC

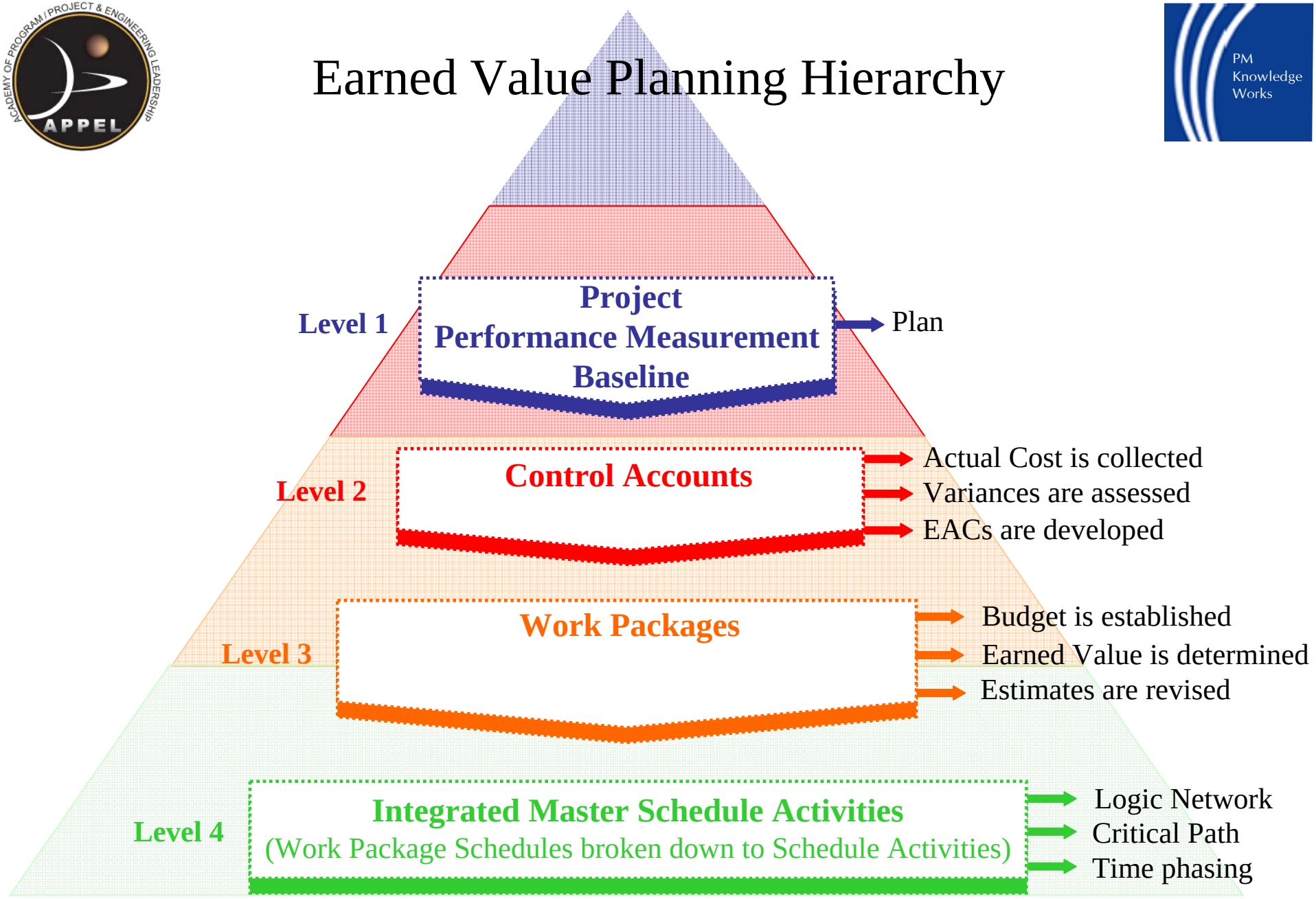
Total Cost Distribution



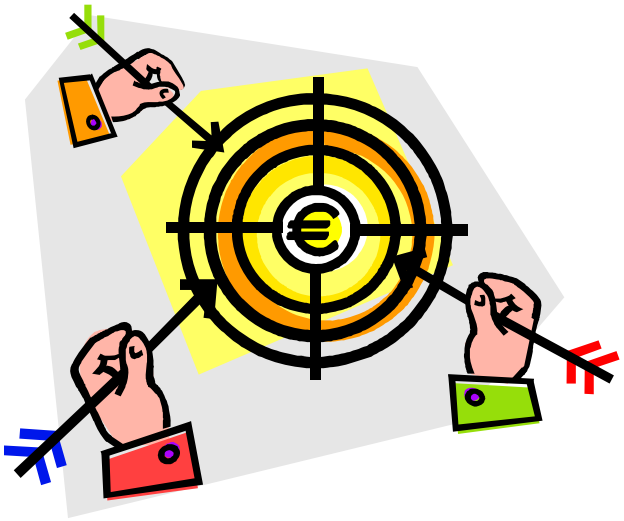
Project Cost and Schedule Margin/Reserves Breakdown Structure



Earned Value Planning Hierarchy

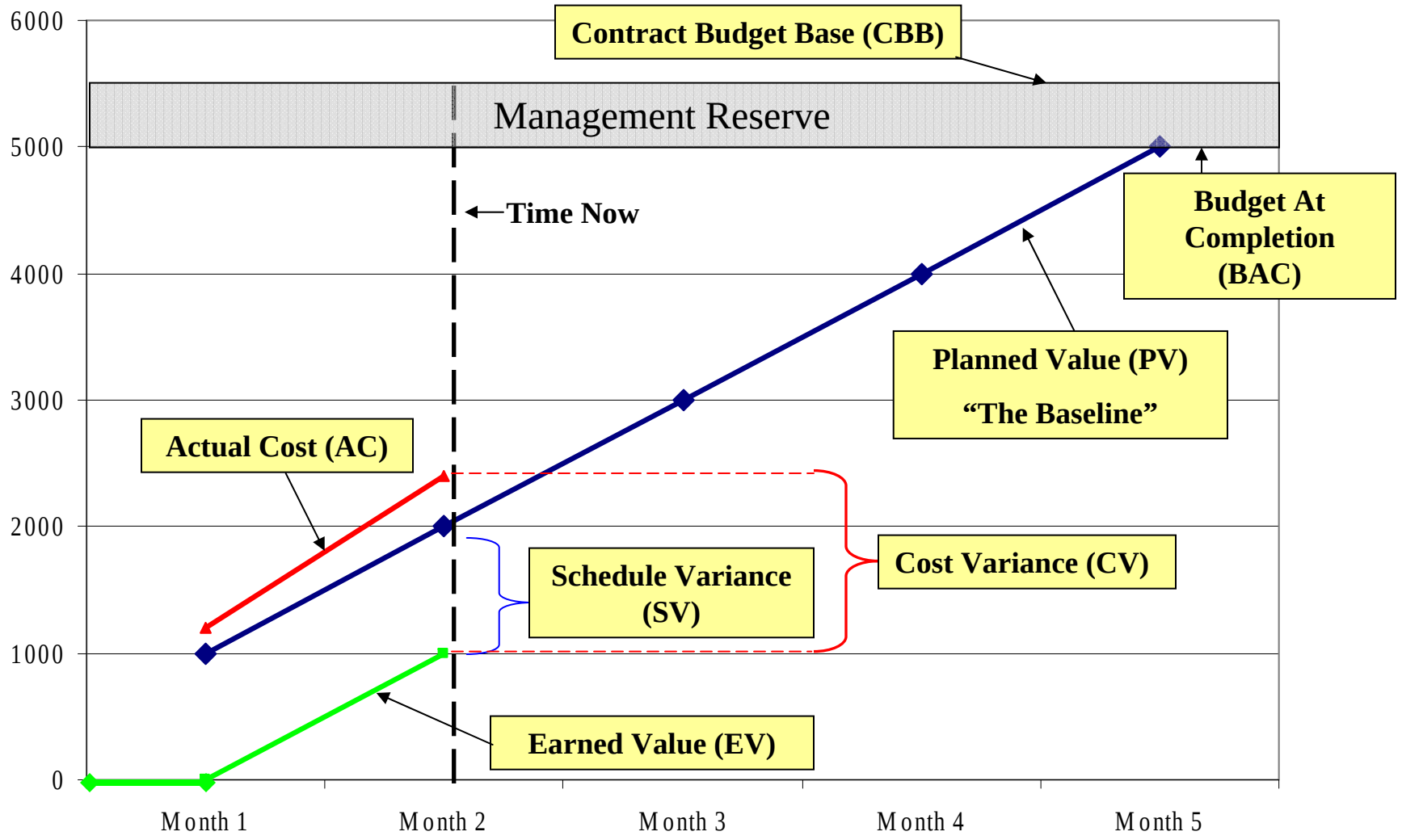


Earned Value Analysis



How can I use EVM to forecast my project's future performance?

EVM Project Performance Chart



Earned Value Formulas

Cost Variance (CV): = EV-AC

Schedule Variance (SV): = EV-PV

Variance at Completion (VAC): = BAC – EAC

Cost Variance Percentage (CV%): = $\frac{CV}{EV}$

Schedule Variance Percentage (SV%): = $\frac{SV}{PV}$

Cost Performance Index (CPI): = $\frac{EV}{AC}$

Schedule Performance Index (SPI): = $\frac{EV}{PV}$

To Complete Performance Index (TCPI): = $\frac{BAC - EV}{EAC - AC}$

Percent Complete: = $\frac{EV}{BAC}$

Percent Spent: = $\frac{AC}{EAC \text{ (or } BAC)}$

Planned Percent Complete: = $\frac{PV}{BAC}$

Grassroots/Calculated EAC: = AC + ETC

Independent EAC #1: = $\frac{BAC}{CPI}$

Independent EAC #2: = AC + $\frac{BAC - EV}{CPI \times SPI}$

Variance Analysis Exercise

FireSat Truss Manufacture CAP
Cumulative Data

Work Package	PV	EV	AC	BAC	EAC
Operations Management	2,500	2,500	2,000	3,000	3,000
Truss Fabrication	7,000	7,000	7,700	7,000	7,000
Kit Truss Assembly	400	400	400	400	400
Truss Final Assembly	17,400	12,600	19,500	20,000	21,000
Total CAP	**27,300**	**22,500**	**29,600**	**30,400**	**31,400**

EVM Analysis Exercise

- Calculate the values needed to complete the table below

	CV	SV	VAC	CPI	SPI	TCPI
Operations Management						
Truss Fabrication						
Kit Truss Assembly						
Truss Final Assembly						
Total CAP						

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Variance Analysis Exercise Answers

	CV	SV	VAC	CPI	SPI	TCPI
Operations Management	500	0	0	1.250	1.000	0.500
Truss Fabrication	-700	0	0	0.909	1.000	n/a
Kit Truss Assembly	0	0	0	1.000	1.000	n/a
Truss Final Assembly	-6,900	-4,800	-1,000	0.646	0.724	4.933
Total CAP	-7,100	-4,800	-1,000	0.760	0.824	4.389

Comparative Analysis Exercise

Tile and Mechanism Build CAP

February Cumulative Data

	PV	EV	AC	SV	SV%	CV	CV%	BAC	EAC	VAC	VAC%
Management	4,000	4,000	3,800	0	0%	200	5%	7,000	7,200	-200	-3%
Mechanisms	12,900	7,090	10,450	-5,810	-45%	-3,360	-47%	14,000	15,000	-1,000	-7%
Tile Manufacture	23,450	20,579	15,000	-2,871	-12%	5,579	27%	25,000	25,000	0	0%
Procedures	5,000	5,000	6,120	0	0%	-1,120	-22%	5,000	5,730	-730	-15%
Total CAP	**45,350**	**36,669**	**35,370**	**-8,681**	**-19%**	**1,299**	**4%**	**51,000**	**52,930**	**-1,930**	**-4%**

Monthly Status Review Exercise

	PV	EV	AC	SV	SPI	CV	CPI	BAC	EAC	VAC	TCPI
Management	10,230	10,230	9,000	0	1.00	1,230	1.14	75,000	75,000	0	0.98
Electronics	13,540	5,460	8,378	-8,080	0.40	-2,918	0.65	87,000	88,000	-1,000	1.02
Structure	35,000	32,578	43,000	-2,422	0.93	-10,422	0.76	96,789	101,000	-4,211	1.11
Detectors	54,000	45,300	53,288	-8,700	0.84	-7,988	0.85	120,000	123,000	-3,000	1.07
Cooler	32,200	32,200	17,000	0	1.00	15,200	1.89	32,200	20,000	12,200	0.00
Total	144,970	125,768	130,666	-19,202	0.87	-4,898	0.96	410,989	407,000	3,989	1.03

Estimate at Completion

Estimate at Completion = Money already spent on project + Money you will spend to complete project

$$EAC = AC + \frac{BCWR}{\text{Performance Factor}}$$

$$\mathbf{EAC = AC + \frac{BAC - EV}{\text{Performance Factor}}}$$

Performance Factors

- Single Index
  - CPI (cumulative, current, last 3 months or last 6 months)
  - SPI (cumulative or current)
- Composite
  - CPI * SPI
- Weighted
  - (0.8*CPI)+(0.2*SPI)

$$EAC = AC + \frac{(BAC-EV)}{\text{Performance Factor}}$$

EAC Exercise

February Cumulative Data

	PV	EV	AC	SV	SV%	CV	CV%	BAC	EAC	VAC	VAC%
Management	4,000	4,000	3,800	0	0%	200	5%	7,000	7,200	-200	-3%
Mechanisms	12,900	7,090	10,450	-5,810	-45%	-3,360	-47%	14,000	15,000	-1,000	-7%
Tile Manufacture	23,450	20,579	15,000	-2,871	-12%	5,579	27%	25,000	25,000	0	0%
Procedures	5,000	5,000	6,120	0	0%	-1,120	-22%	5,000	5,730	-730	-15%
Total CAP	**45,350**	**36,669**	**35,370**	**-8,681**	**-19%**	**1,299**	**4%**	**51,000**	**52,930**	**-1,930**	**-4%**

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EAC Analysis Exercise Answers

	PV	EV	BAC	BAC-EV	CPI	Estimate to Complete	AC	Estimate At Completion
Management	4,000	4,000	7,000	3,000	1.053	2,850	3,800	6,650
Mechanisms	12,900	7,090	14,000	6,910	0.678	10,185	10,450	20,635
Tile Manufacture	23,450	20,579	25,000	4,421	1.372	3,222	15,000	18,222
Procedures	5,000	5,000	5,000	0	0.817	0	6,120	6,120
Total CAP	**45,350**	**36,669**	**51,000**	**14,331**	**1.037**	**13,823**	**35,370**	**49,193**
Note: If the individual estimates at completion were added, the total is 51,627 instead of 49,193.								

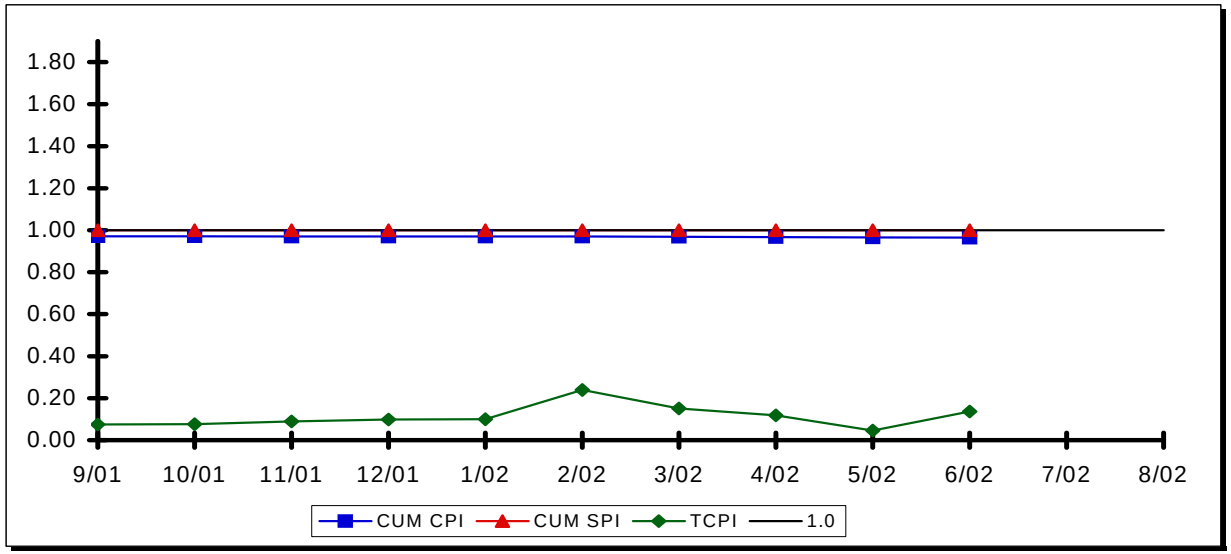
EAC for Class MSR Exercise

	PV	EV	BAC	BAC-EV	CPI	Estimate to Complete	AC	Estimate at Completion
Management	10,230	10.230	75,000	64,770	1.137	56,982	9,000	65,982
Electronics	13,540	5,460	87,000	81,450	0.652	125,118	8,378	133,496
Structure	35,000	32,578	96,789	64,211	0.758	84,753	43,000	127,753
Detectors	54,000	45,300	120,000	74,700	0.850	87,872	53,288	141,160
Cooler	32,200	32,200	32,200	0	1.894	0	17,000	17,000
Total	144,970	125,768	410,989	285,221	0.963	296,329	130,666	426,995

Example Variance Explanation

TIROS SUMMARY PERFORMANCE CHART M/E **Jun-02**

KXXX - DESIGN ENG. KLM MANAGER **OBS** **KXXX Team**



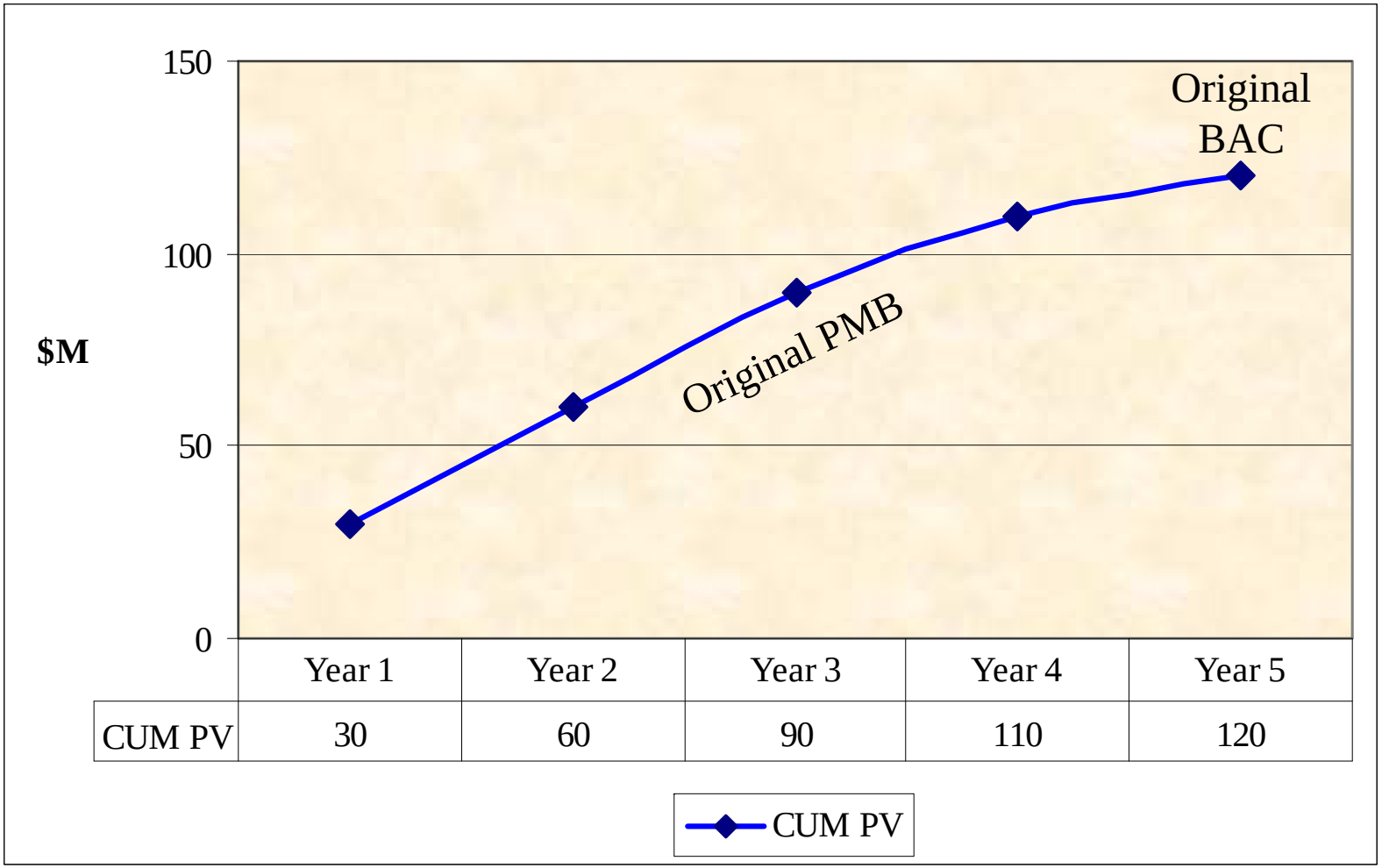
THOUSANDS ($000)	MONTHLY	CUM
CV	($53)	($1,170)
CV%	-2650%	-4%
SV	$1	$0
SV%	100%	0%
CPI	0.04	0.96
SPI	2.00	1.00
TCPI		0.14
BAC		$32,131
EAC		$33,320
VAC		($1,189)
DELTA VAC		($30)
% COMP		99.99%
% SPENT		99.9%

Cost / Schedule Cost Variance:

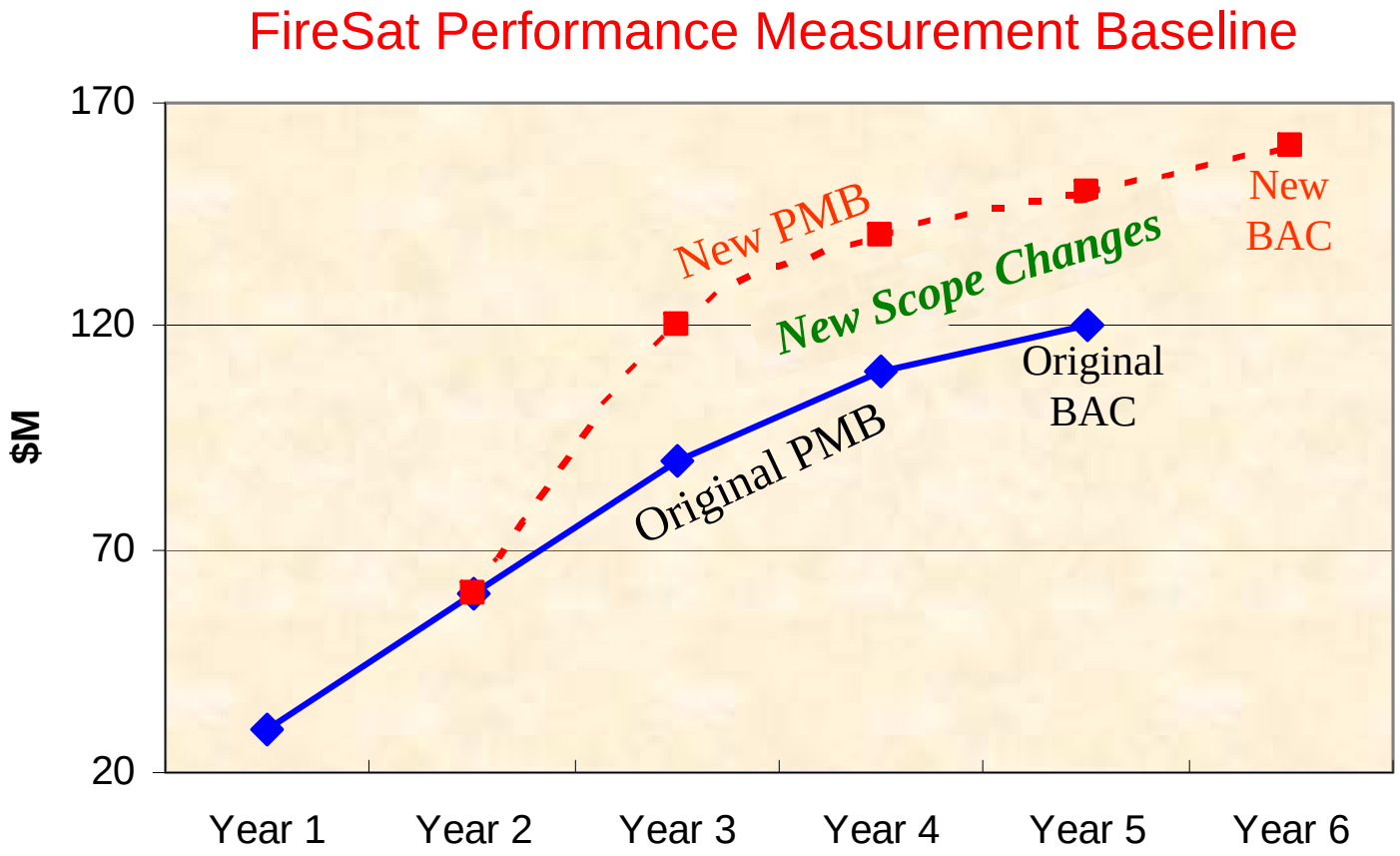
Cumulative: The cumulative unfavorable cost variance is primarily caused by effort on the S-Band Antenna. Additional manpower was applied to meet the "L" schedule date. The variance is also impacted by Skill Center Support utilization of Engineers to assist with DR closure.

Revising the PMB

FireSat Performance Measurement Baseline

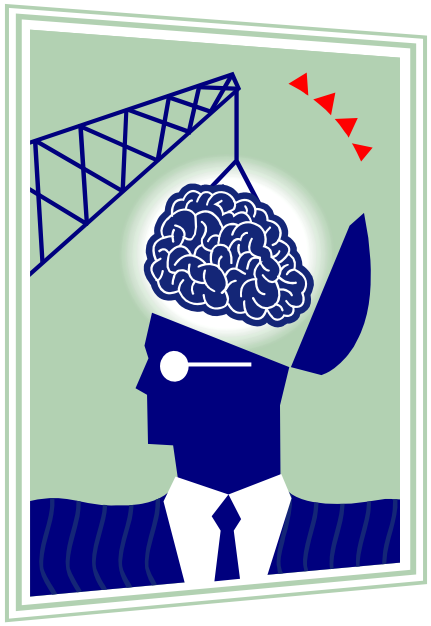


Revising the PMB



Effect of new scope changes on original Performance Measurement Baseline

Lunar Surface Oxygen Supply System (LSOSS): Integrated Project Management Case Study



Capstone Exercise – LSOSS Project

- You have been assigned as Project Manager for the Lunar Surface Oxygen Supply System (LSOSS) project
- LSOSS began Phase C about two years ago and is apparently a successful project
- The last Project Manager, Sam, is moving to a higher level job and tells you that he has forecast an under run for the project
- He gave the following status information at last month's MSR:

Cum budget through last month:	$350,970K
Cum actual cost through last month:	$253,751K
Total run out cost:	$725,000K

Capstone Exercise Background

- Sam says the project is about half done and many of the early technical challenges are solved. You ask how he has determined the percent completion and he said that it's a gut feel based on years of experience
- Sam has a reputation of leaving projects just before things start falling apart
- You must report your assessment, including your independently generated EAC, of LSOSS status at a Center Management Council (CMC) in three weeks
- You gather all reports and organize the following data

LSOSS Project Status

- LSOSS Project Monthly Status Review charts indicate that the project has consistently under run the budget since inception
- In the S&MA and Mission Management WBS elements, you cannot identify any discrete work with which to base your assessment of percent complete. These areas lack any measurable performance activities, and you decide they behave consistently with the level of effort (LOE) EVM technique as you prepare your new EAC
- The following information is available from project files:

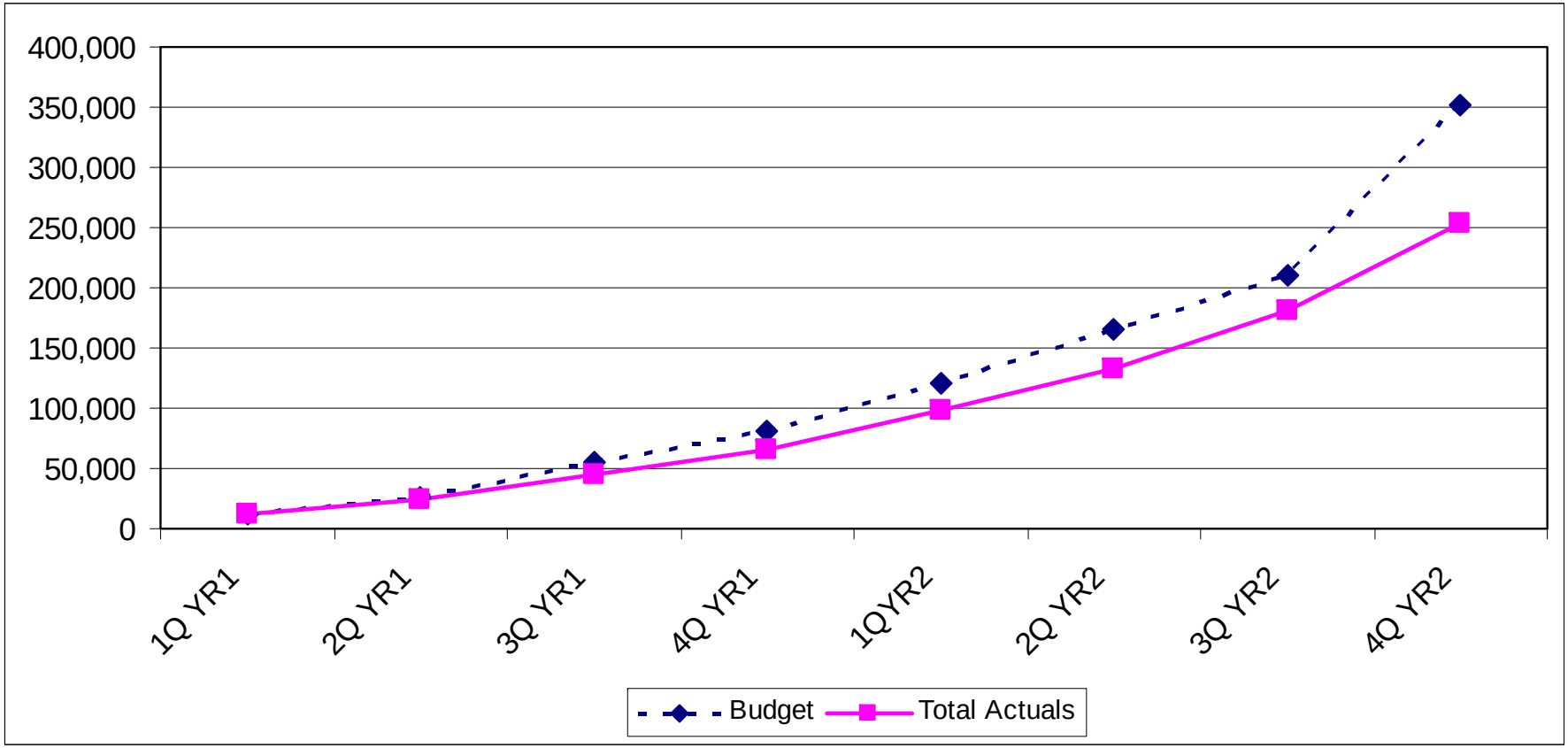
LSOSS Cumulative Budget vs Cumulative Actual Data ($K)

	Budget at Completion	Grassroots EAC	Last Month's Cum Budget	Last Month's Cum Actual Cost
Spacecraft	125,000	125,000	55,900	33,251
ISRU	225,000	225,000	170,070	175,500
S&MA	60,000	60,000	35,000	20,250
Mission Management	95,000	95,000	40,000	14,750
Launch Vehicle	130,000	130,000	50,000	10,000
Operations	90,000	90,000	0	0
Total	**725,000**	**725,000**	**350,970**	**253,751**

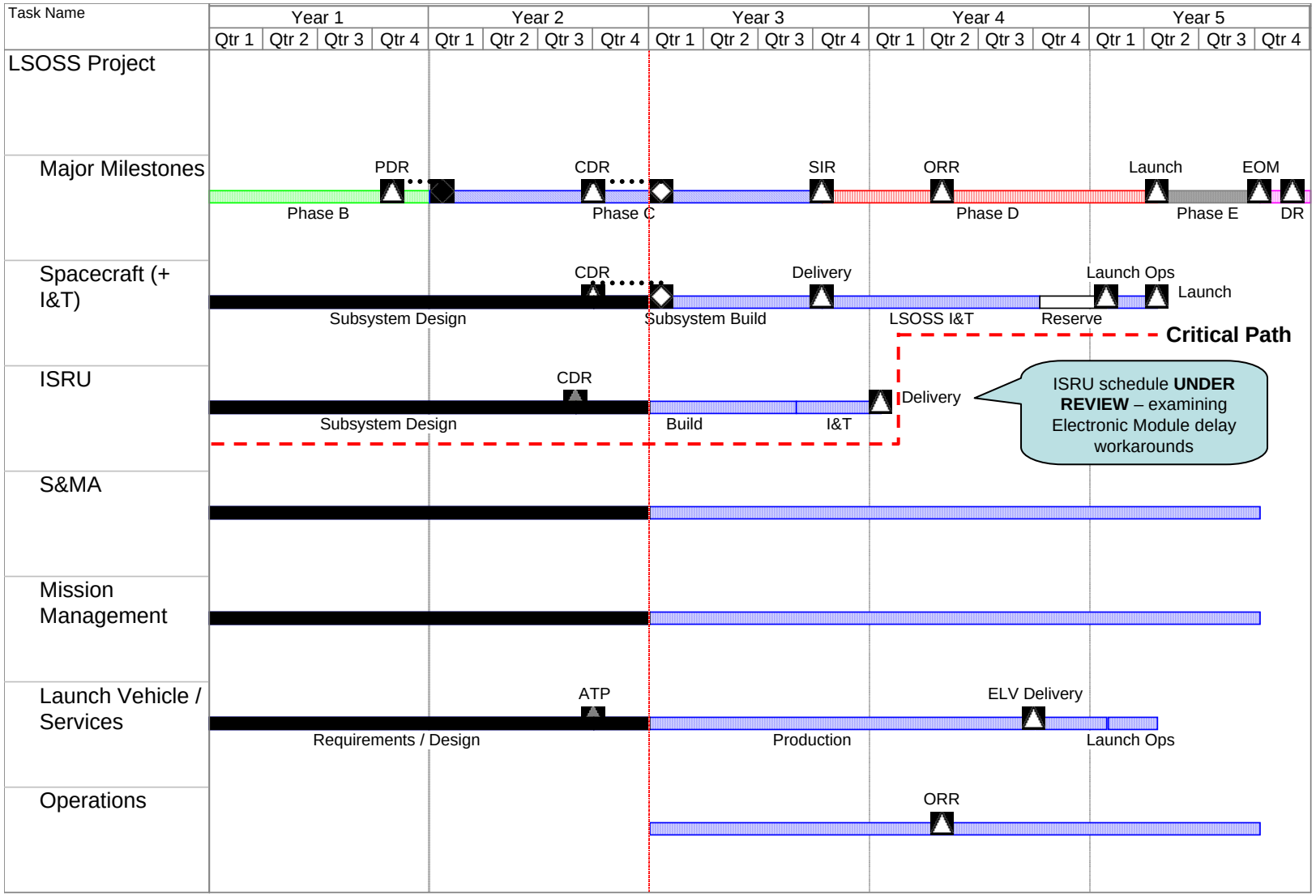
LSOSS Cumulative Actual Cost by Major System Historical Data ($K)

	1Q YR1	2Q YR1	3Q YR1	4Q YR1	1Q YR2	2Q YR2	3Q YR2	4Q YR2
Actuals:								
Spacecraft	1,060	3,049	8,594	13,958	18,594	21,096	28,490	33,251
ISRU	8,502	17,269	29,605	41,290	61,049	85,940	119,289	175,500
S&MA	1,092	2,589	4,368	6,159	8,597	10,543	12,690	20,250
Mission Management	928	1,307	1,970	4,708	7,480	10,469	12,679	14,750
Launch Vehicle					2,500	5,000	7,500	10,000
Operations								
Total Actuals	11,582	24,214	44,537	66,115	98,220	133,048	180,648	253,751
Budget	12,504	25,049	54,321	81,087	120,865	165,787	210,987	350,970
Over (Under) Budget	(922)	(835)	(9,784)	(14,972)	(22,645)	(32,739)	(30,339)	(97,219)

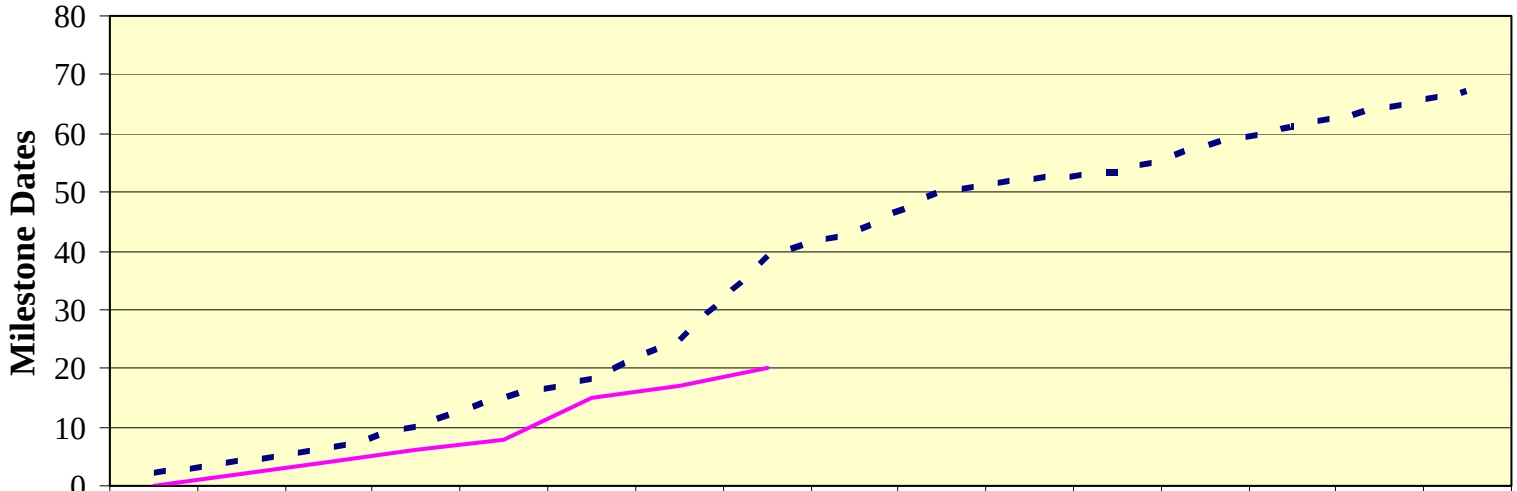
LSOSS Monthly Financial Status $K



LSOSS Project Master Schedule



LSOSS Project Control Milestone Performance



	Q1 Yr	Q2 Y1	Q3 Y1	Q4 Y1	Q1 Y2	Q2 Y2	Q3 Y2	Q4 Y2	Q1 Y3	Q2 Y3	Q3 Y3	Q4 Y3	Q1 Y4	Q2 Y4	Q3 Y4	Q4 Y4
Plan	2	4	6	10	15	18	25	39	43	50	52	53	58	61	64	67
Actual	0	2	4	6	8	15	17	20								

LSOSS Total Slack – Month 24

	Total Slack - Work Days			
Level 2 WBS / Control Accounts	**Baseline**	**Month 23**	**Month 24**	**Driver**
LSOSS ISRU	40	-50	-60	Late Electronics Module
LSOSS S/C Mechanical Subsystem	54	-10	15	Structure
LSOSS S/C Propulsion Subsystem	40	20	20	Thrusters
LSOSS S/C Attitude Control Subsystem	66	66	66	ACS Flight Software Build 3
LSOSS S/C Power Subsystem	32	30	25	PSDU
LSOSS S/C C&DH Subsystem	22	5	-1	RTT "A" Side
LSOSS S/C Communications Subsystem	60	60	50	Transponder
LSOSS S/C Electrical Subsystem	30	30	40	Main harness
LSOSS Integration & Test (LSOSS Ready to ship)	22	-50	-60	ISRU
LSOSS Ground System	50	50	50	POCC Build #3

Spacecraft Information

- The spacecraft vendor has delayed your cost plus award fee (CPAF) contract in order to complete a higher priority fixed price (FP) commercial contract.
- At the contractor's suggestion, the EVM reporting requirement was removed from the contract last year. The contractor estimated a savings of $1M due to decreased level of cost and variance reporting.
- By examining the contractor reports and schedules, you estimate the spacecraft is 20% complete.

ISRU Information

- Delayed availability of I&T personnel for the electronics module has caused a schedule delay for the ISRU, as evidenced by the critical path
- Best Aerospace company, the ISRU developer, is required to submit monthly EVM data including key trend graphs

ISRU Contract Performance Report

CLASSIFICATION (When Filled In)

CONTRACT PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE DOLLARS IN _____

FORM APPROVED
OMB No. 0704-0188

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME: Best Aerospace Company	a. NAME: LSOSS ISRU	a. NAME	a. FROM (YYYYMMDD): Nov 30, Year 2
b. LOCATION (Address and ZIP Code)	b. NUMBER: NAS7-384950	b. PHASE	b. TO (YYYYMMDD): Dec 30, Year 2
	c. TYPE: CPAF; d. SHARE RATIO	c. EVMS ACCEPTANCE: NO YES (YYYYMMDD)	

5. CONTRACT DATA								
a. QUANITY	b. NEGOTIATED COST	c. ESTIMATED COST OF AUTHORIZED UNPRICED WORK	d. TARGET PROFIT/ FEE	e. TARGET PRICE	f. ESTIMATED PRICE	g. CONTRACT CEILING	h. ESTIMATED CONTRACT CEILING	i. DATE OF OTB/OTS (YYYYMMDD)

6. ESTIMATED COST AT COMPLETION	MANAGEMENT ESTIMATE AT COMPLETION (1)	CONTRACT BUDGET BASE (2)	VARIANCE (3)
a. BEST CASE			
b. WORST CASE			
c. MOST LIKELY			

7. AUTHORIZED CONTRACTOR REPRESENTATIVE		
a. NAME (Last, First, Middle Initial): Smith, Jane	b. TITLE: Project Manager	
c. SIGNATURE		d. DATE SIGNED (YYYYMMDD)

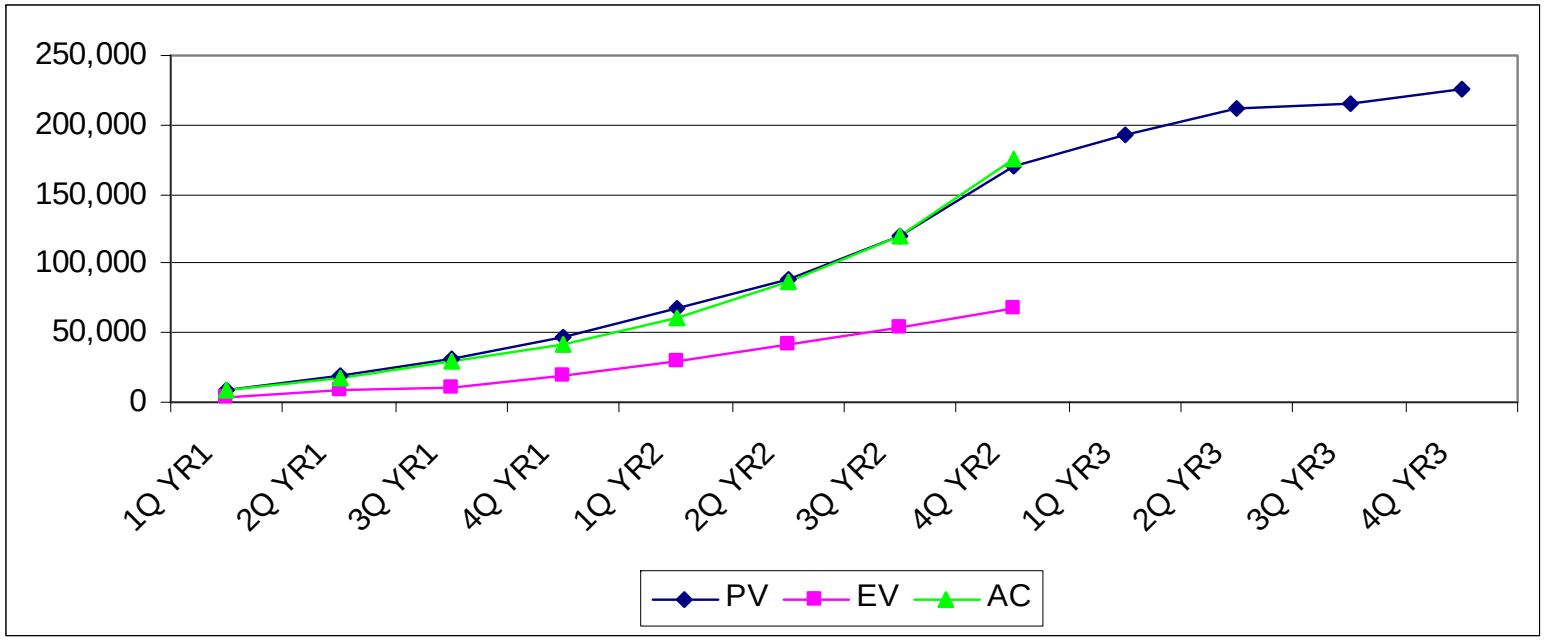
8. PERFORMANCE DATA

ITEM (1)	CURRENT PERIOD: PLANNED VALUE (2)	EARNED VALUE (3)	ACTUAL COST (4)	VARIANCE SCHEDULE (5)	VARIANCE COST (6)	CUMULATIVE TO DATE: PLANNED VALUE (7)	EARNED VALUE (8)	ACTUAL COST (9)	VARIANCE SCHEDULE (10)	VARIANCE COST (11)	REPROGRAMMING ADJUSTMENTS: COST VARIANCE (12a)	SCHEDULE VARIANCE (12b)	BUDGET (13)	AT COMPLETION: BAC (14)	EAC (15)	VARIANCE (16)
a. WORK BREAKDOWN STRUCTURE ELEMENT																
Management						4,356	4,356	5,914	0	-1,558				5,356	5,356	0
Systems Engineering						5,079	5,076	7,090	-3	-2,014				6,079	6,079	0
Electronics Module						64,499	6,684	17,619	-57,815	-10,935				80,879	80,879	0
Structure						36,940	36,940	96,980	0	-60,040				36,940	36,940	0
Detectors						29,970	3,567	15,261	-26,403	-11,694				29,970	29,970	0
Cooler						12,646	4,890	14,180	-7,756	-9,290				12,646	12,646	0
I&T						0	0	0	0	0				8,665	8,665	0
Post delivery support						0	0	0	0	0				21,415	21,415	0
b. COST OF MONEY																
c. GENERAL AND ADMINISTRATIVE						16,580	5,987	18,456	-10,593	-12,469				21,000	21,000	0
d. UNDISTRIBUTED BUDGET														2,050	2,050	0
e. SUB TOTAL (PERFORMANCE MEASUREMENT BASELINE)	0	0	0	0	0	170,070	67,500	175,500	-102,570	-108,000				225,000	225,000	0
f. MANAGEMENT RESERVE														0		
g. TOTAL	0	0	0	0	0	170,070	67,500	175,500	-102,570	-108,000	0	0	0	225,000		
9. RECONCILIATION TO CONTRACT BUDGET BASE																
a. VARIANCE ADJUSTMENT																
b. TOTAL CONTRACT VARIANCE																

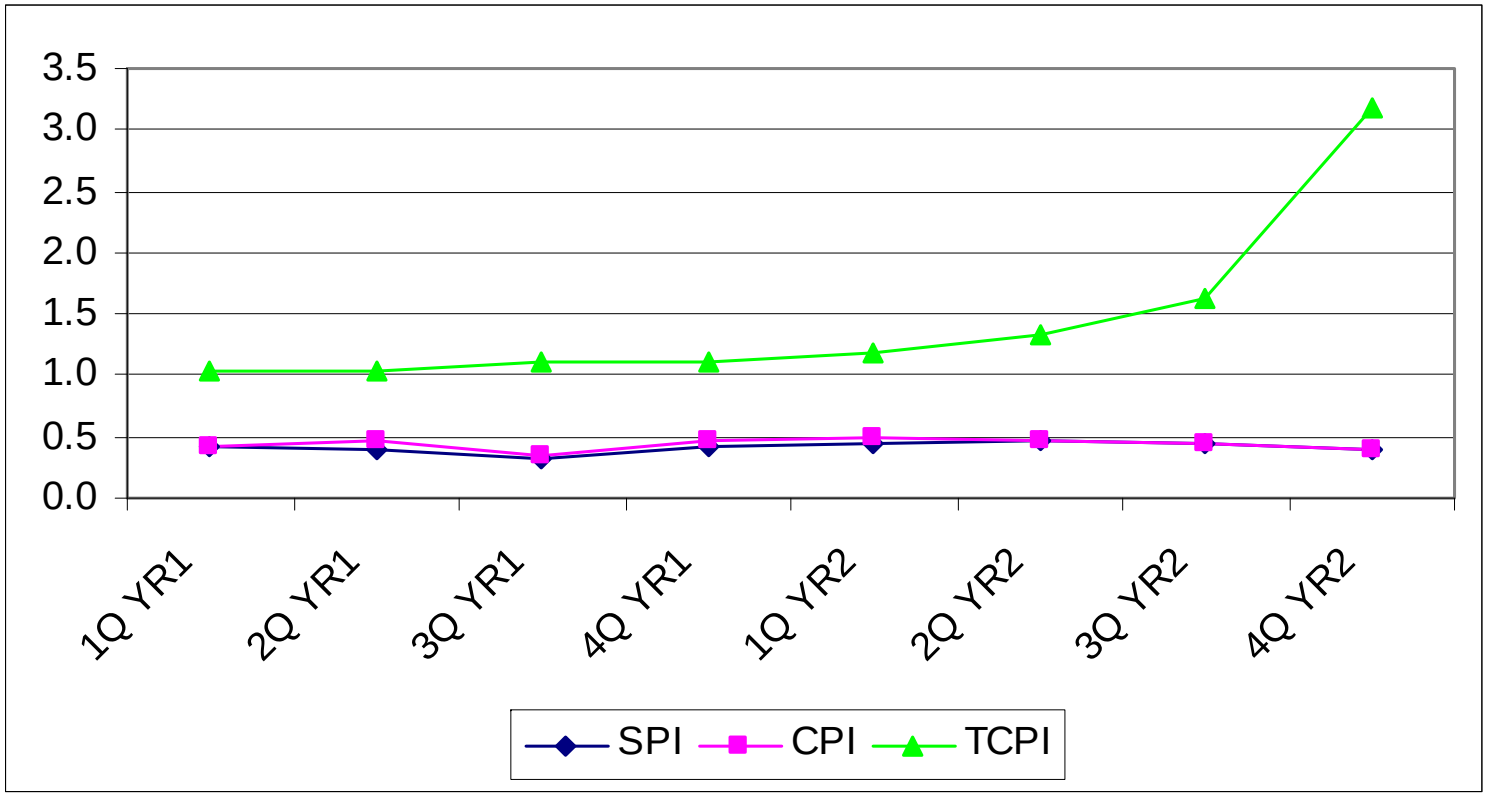
ISRU Cost Performance Data Cum thru December Year 2 ($K)

	PV	EV	AC	SV	CV	BAC	EAC	VAC
Management	4,356	4,356	5,914	0	-1,558	5,356	5,356	0
Systems Engineering	5,079	5,076	7,090	-3	-2,014	6,079	6,079	0
Electronics Module	64,499	6,684	17,619	-57,815	-10,935	80,879	80,879	0
Structure	36,940	36,940	96,980	0	-60,040	36,940	36,940	0
Detectors	29,970	3,567	15,261	-26,403	-11,694	29,970	29,970	0
Cooler	12,646	4,890	14,180	-7,756	-9,290	12,646	12,646	0
I&T	0	0	0	0	0	8,665	8,665	0
Post Delivery Support	0	0	0	0	0	21,415	21,415	0
General and Administrative	16,580	5,987	18,456	-10,593	-12,469	21,000	21,000	0
Undistributed Budget						2,050	2,050	0
PMB	170,070	67,500	175,500	-102,570	-108,000	225,000	225,000	0
Management Reserve						0		
Total Contract Budget Base	170,070	67,500	175,500	-102,570	-108,000	225,000		

ISRU EVM Data $K



ISRU Performance Indices



ISRU Historical Cumulative Performance Trend Data ($K)

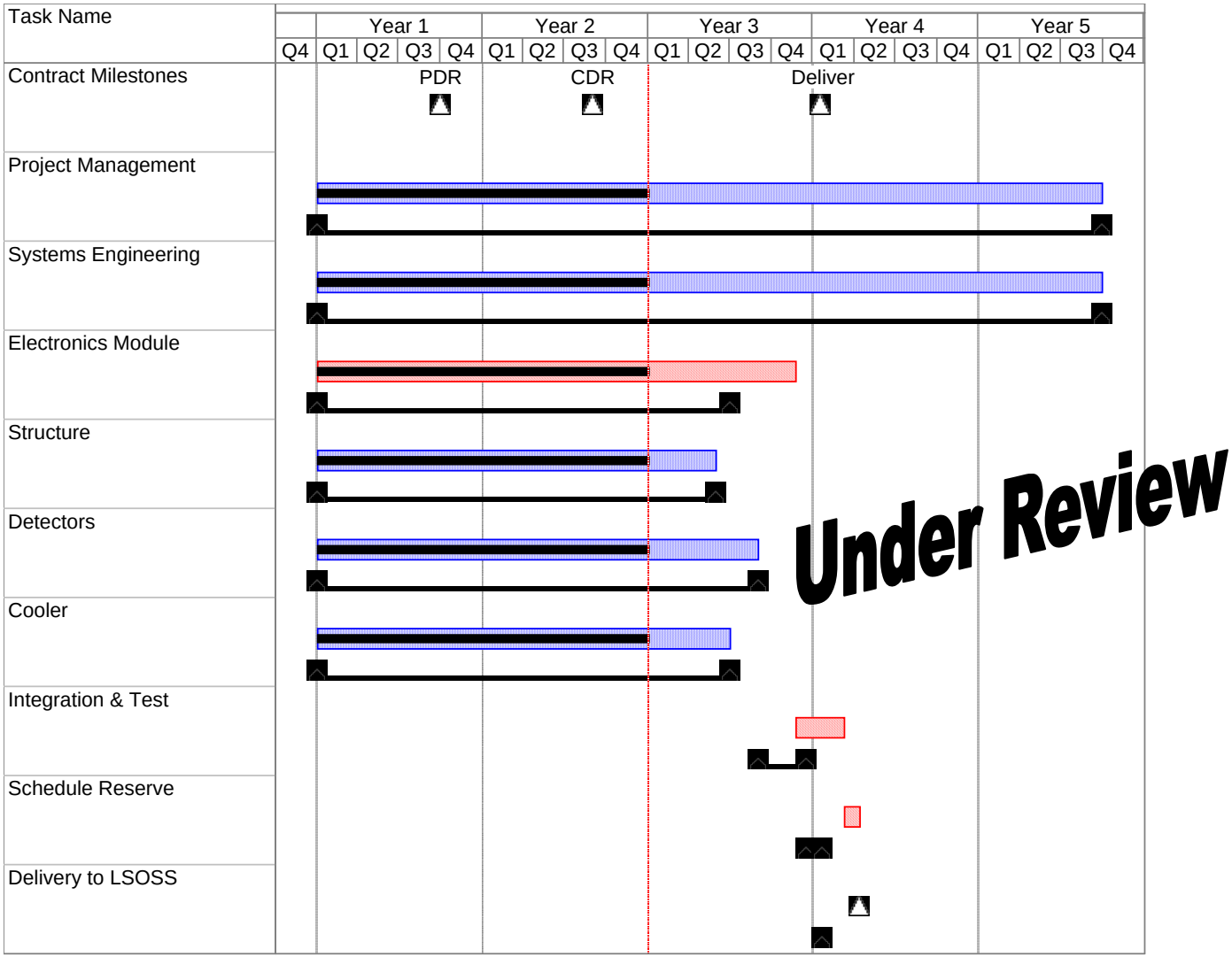
	1Q YR1	2Q YR1	3Q YR1	4Q YR1	1Q YR2	2Q YR2	3Q YR2	4Q YR2
PV	**8,430**	**19,804**	**31,204**	**46,950**	**67,950**	**89,403**	**120,589**	**170,070**
EV	**34,598**	**7,894**	**10,298**	**19,827**	**29,580**	**41,029**	**53,209**	**67,500**
AC	**8,502**	**17,269**	**29,605**	**41,290**	**61,049**	**85,940**	**119,289**	**175,500**
SV	**(4,971)**	**(11,910)**	**(20,906)**	**(27,123)**	**(38,370)**	**(48,374)**	**(67,380)**	**(102,570)**
CV	**(5,043)**	**(9,375)**	**(19,307)**	**(21,463)**	**(31,469)**	**(44,911)**	**(66,080)**	**(108,000)**
SPI	**0.4103**	**0.3986**	**0.3300**	**0.4223**	**0.4353**	**0.4589**	**0.4412**	**0.3969**
CPI	**0.4068**	**0.4571**	**0.3478**	**0.4802**	**0.4845**	**0.4774**	**0.4461**	**0.3846**
TCPI	**1.0233**	**1.0451**	**1.0988**	**1.1168**	**1.1919**	**1.3230**	**1.6251**	**3.1818**
EAC	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**
BAC	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**
IEAC*								
Potential Overrun**								

For simplicity use this formula:

$$*\text{IEAC} = \frac{\text{BAC}}{\text{CPI}}$$

** Potential Overrun = BAC - IEAC

ISRU Master Schedule



Launch Vehicle Information

- HQ held back funding due to a Congressional budget cut in Year 2, so only $10M has been sent to the launch vehicle vendor
- Sam forwarded the following two relevant e-mails to you concerning the Launch Vehicle:

E-mail Message 1

Date: January 10, Year 3

From: Alice/KSC/Launch Vehicle Manager

To: Sam/LSOSS Project Manager

As of last month, we completed the first four milestones and made payments totaling $10M to Boeing. When can we expect additional funding for the remaining work?

E-mail Message 2

Date: January 15, Year 3

From: Ted/HQ/ESMD

To: Sam/LSOSS Project Manager

We realize you are in a difficult spot funding your project activities (especially the Launch Vehicle funding to KSC) given the Congressionally mandated cut of $40M last year. We are trying to realign some other funds to help you out. We should know how much funding we can scrape up for you by early January. Hang in there!

EVM Discussion

1. What is the real percent complete?
2. What is the percent spent?
3. What is the planned percent complete through time now?
4. At the upcoming PMC, what should your assessment of LSOSS status be? (include your assessment of the potential EAC)

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Spacecraft $K

PV	= 55,900
EV	= 25,000 (125,000 x .20)
AC	= 33,251
BAC	= 125,000
Grassroots EAC	= 125,000
CPI	= 0.75
SPI	= 0.45
TCPI	= 1.09
Percent Complete	= 20%
Percent Spent	= 27%
Planned Percent Complete	= 45%

EAC based on past performance

$$EAC = AC + \frac{(BAC - EV)}{\text{Perf. Factor}}$$

$$= 33{,}251 + \frac{(125{,}000 - 25{,}000)}{0.75}$$

$$= 33{,}251 + 133{,}333$$

$$= 166{,}584$$

ISRU $K

PV = 170,070

EV = 67,500 (225,000 x .3)

AC = 175,500

BAC = 225,000

Grassroots EAC = 225,000

CPI = 0.38

SPI = 0.40

TCPI = 3.18

Percent Complete = 30%

Percent Spent = 78%

Planned Percent Complete = 76%

EAC based on past performance

$$EAC = AC + \frac{(BAC - EV)}{\text{Perf. Factor}}$$

$$= 175{,}500 + \frac{(225{,}000 - 67{,}500)}{0.38}$$

$$= 175{,}500 + \frac{157{,}500}{0.38}$$

$$= 175{,}500 + 414{,}473$$

$$= 589{,}973$$

S + MA $K

PV	= 35,000
EV	= 35,000 (LOE)
AC	= 20,250
BAC	= 60,000
Grassroots EAC	= 60,000
CPI	= 1.73
SPI	= 1.00
TCPI	= 0.63
Percent Complete	= 58%
Percent Spent	= 34%
Planned Percent Complete	= 58%

EAC based on past performance

$$EAC = AC + \frac{(BAC - EV)}{\text{Perf. Factor}}$$

$$= 20{,}250 + \frac{(60{,}000 - 35{,}000)}{1.73}$$

$$= 20{,}250 + \frac{25{,}000}{1.73}$$

$$= 20{,}250 + 14{,}450$$

$$= 34{,}700$$

How realistic is this estimate?

Mission Management $K

PV	= 40,000
EV	= 40,000 (LOE)
AC	= 14,750
BAC	= 95,000
Grassroots EAC	= 95,000
CPI	= 2.71
SPI	= 1.00
TCPI	= 0.69
Percent Complete	= 42%
Percent Spent	= 16%
Planned Percent Complete	= 42%

EAC based on past performance

$$EAC = AC + \frac{(BAC - EV)}{\text{Perf. Factor}}$$

$$= 14{,}750 + \frac{(95{,}000 - 40{,}000)}{2.71}$$

$$= 14{,}750 + \frac{55{,}000}{2.71}$$

$$= 14{,}750 + 20{,}295$$

$$= 35{,}045$$

What conclusions can you reach about forecasting LOE accounts?

Launch Vehicle $K

PV	= 50,000
EV	= 10,000
AC	= 10,000
BAC	= 130,000
Grassroots EAC	= 130,000
CPI	= 1.00
SPI	= 0.20
TCPI	= 1.00
Percent Complete	= 8%
Percent Spent	= 8%
Planned Percent Complete	= 38%

EAC based on past performance

$$EAC = AC + \frac{(BAC - EV)}{\text{Perf. Factor}}$$

$$= 10{,}000 + \frac{(130{,}000 - 10{,}000)}{1.00}$$

$$= 10{,}000 + \frac{120{,}000}{1.00}$$

$$= 10{,}0000 + 120{,}000$$

$$= 130{,}000$$

Total Project $K

PV = 350,970

EV = 177,500 (Add level 2 WBS amounts)

AC = 253,751

BAC = 725,000

Grassroots EAC = 725,000

CPI = 0.70

SPI = 0.51

TCPI = 1.16

Percent Complete = 24%

Percent Spent = 35%

Planned Percent Complete = 48%

EAC based on past performance

$$EAC = AC + \frac{(BAC - EV)}{\text{Perf. Factor}}$$

$$= 253{,}751{,}123 + \frac{(725{,}000 - 177{,}500)}{0.70}$$

$$= 253{,}751 + \frac{547{,}500}{0.70}$$

$$= 253{,}751 + 782{,}142$$

$$= 1{,}035{,}893$$

LSOSS EVM Analysis $K

	Last Month's Cum EV	Percent Complete	Percent Spent	Planned Percent Complete	CPI	SPI	TCPI	IEAC*
Spacecraft	25,000	20%	27%	45%	0.75	0.45	1.09	166,667
ISRU	67,500	30%	78%	76%	0.38	0.40	3.18	592,105
S&MA	35,000	58%	34%	58%	1.73	1.00	0.63	34,682
Mission Management	40,000	42%	16%	42%	2.71	1.00	0.69	35,055
Launch Vehicle	10,000	8%	77%	38%	1.00	0.20	1.00	130,000
Operations	0							90,000
Total	**177,500**	24%	35%	48%	0.70	0.51	1.16	1,048,509

*Independent EAC= BAC/CPI

ISRU Historical Cumulative Performance Trend Data ($K)

	1Q YR1	2Q YR1	3Q YR1	4Q YR1	1Q YR2	2Q YR2	3Q YR2	4Q YR2
PV	**8,430**	**19,804**	**31,204**	**46,950**	**67,950**	**89,403**	**120,589**	**170,070**
EV	**3,4598**	**7,894**	**10,298**	**19,827**	**29,580**	**41,029**	**53,209**	**67,500**
AC	**8,502**	**17,269**	**29,605**	**41,290**	**61,049**	**85,940**	**119,289**	**175,500**
SV	**(4,971)**	**(11,910)**	**(20,906)**	**(27,123)**	**(38,370)**	**(48,374)**	**(67,380)**	**(102,570)**
CV	**(5,043)**	**(9,375)**	**(19,307)**	**(21,463)**	**(31,469)**	**(44,911)**	**(66,080)**	**(108,000)**
SPI	**0.4103**	**0.3986**	**0.3300**	**0.4223**	**0.4353**	**0.4589**	**0.4412**	**0.3969**
CPI	**0.4068**	**0.4571**	**0.3478**	**0.4802**	**0.4845**	**0.4774**	**0.4461**	**0.3846**
TCPI	**1.0233**	**1.0451**	**1.0988**	**1.1168**	**1.1919**	**1.3230**	**1.6251**	**3.1818**
EAC	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**
BAC	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**	**225,000**
IEAC*	**553,097**	**492,234**	**646,924**	**468,555**	**464,396**	**471,303**	**504,371**	**585,023**
Potential Overrun**	**(328,097)**	**(267,234)**	**(421,924)**	**(243,555)**	**(239,396)**	**(246,303)**	**(279,371)**	**(360,023)**

For simplicity use this formula:

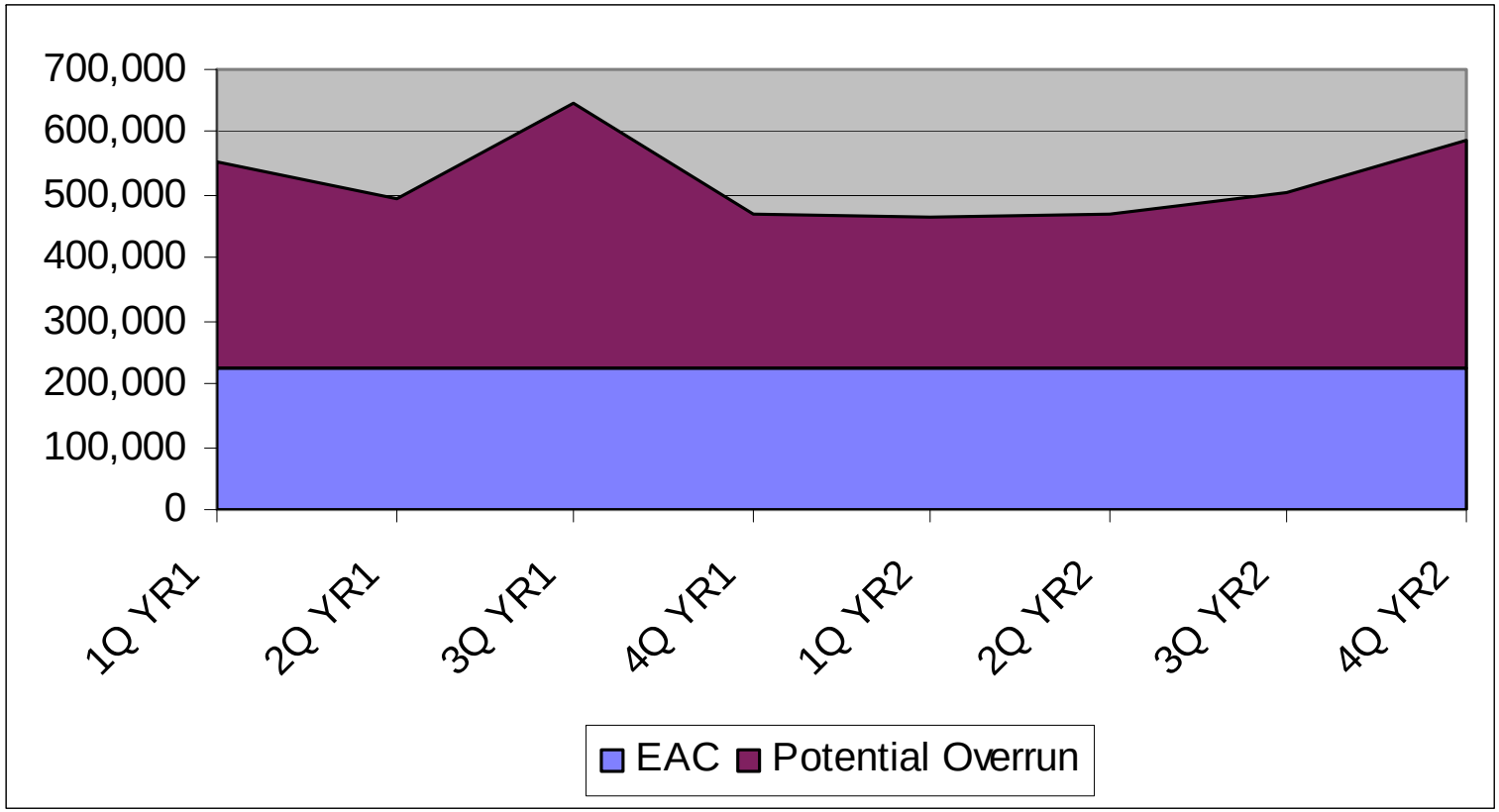
$$*\text{IEAC} = \frac{\text{BAC}}{\text{CPI}}$$

** Potential Overrun = BAC - IEAC

ISRU Independent EAC ($K)

	BAC	CPI	IEAC	Grassroots EAC
Management	5,356	0.7366	7,272	5,356
Systems Engineering	6,079	0.7159	8,491	6,079
Electronics Module	80,879	0.3794	213,197	80,879
Structure	36,940	0.3809	96,980	36,940
Detectors	29,970	0.2337	128,223	29,970
Cooler	12,646	0.3449	36,671	12,646
I&T	8,665		8,665	8,665
Post Delivery Support	21,415		21,415	21,415
General and Administrative	21,000		57,665	21,000
Undistributed Budget	2,050		2,050	2,050
PMB	225,000		580,629	225,000
Management Reserve	0			0
Total Contract Budget Base	225,000		580,629	225,000

ISRU Potential Overrun using BAC/CPI ($K)



Case EVM Analysis: Unrealistic Status

- Assessment of Project:
  - Below spend plan
  - Behind schedule
  - 24% work complete versus 48% planned
  - 35% funds expended for 24% of work
  - Overrun is likely to be in range of $300 - 400M

Case EVM Analysis: Unrealistic Status

- Recommendations:
  - Implement Earned Value Management Reporting immediately- information already exists, but is not integrated and reported
  - Initiate corrective action with both spacecraft and instrument vendors
  - Integrate analysis into cost reports. Report at system level as well as project level

Project Closeout

How do I close out a project?

Project Closeout

- As your project nears it's completion, which is the best course of action?
  a) Hurry up and find a new job
  b) Store all of your records in case you need them again
  c) Start thinking about closing out your project in an organized way
  d) Review and update the project closeout plan that was (hopefully) developed earlier

Project Closeout

- Project closeout encompasses the formal termination or closure of the activities in a project or project phase and verification that the project or phase is finished

NPR 7120.5D - Closeout

- Phase F – Closeout (Projects)
- Purpose: During Phase F, the project implements the Systems Decommissioning/Disposal Plan developed in Phase E, and performs analyses of the returned data and any returned samples

NPR 7120.5D – Closeout Requirements

- During Phase F, the Project Manager and the project team shall:
  - Complete analysis and archiving of mission and science data and curation of any returned samples, as well as archiving project engineering and technical management data and documentation, and lessons learned in accordance with agreements, the Project Plan and Program Plan, and Center and Agency policies

NPR 7120.5D – Closeout Requirements (cont'd)

- During Phase F, the Project Manager and the project team shall:
  - Prior to the project life-cycle reviews . . . Conduct internal reviews in accordance with NPR 7123.1, Center practices, and the requirements of this document
  - Plan, prepare for, and support the project life-cycle reviews . . . in accordance with NPR 7123.1, Center practices, and the requirements of this document
  - Implement the Systems Decommissioning/Disposal Plan and safely dispose of project systems
  - Prepare a final CADRe (Category 1 & 2 projects)

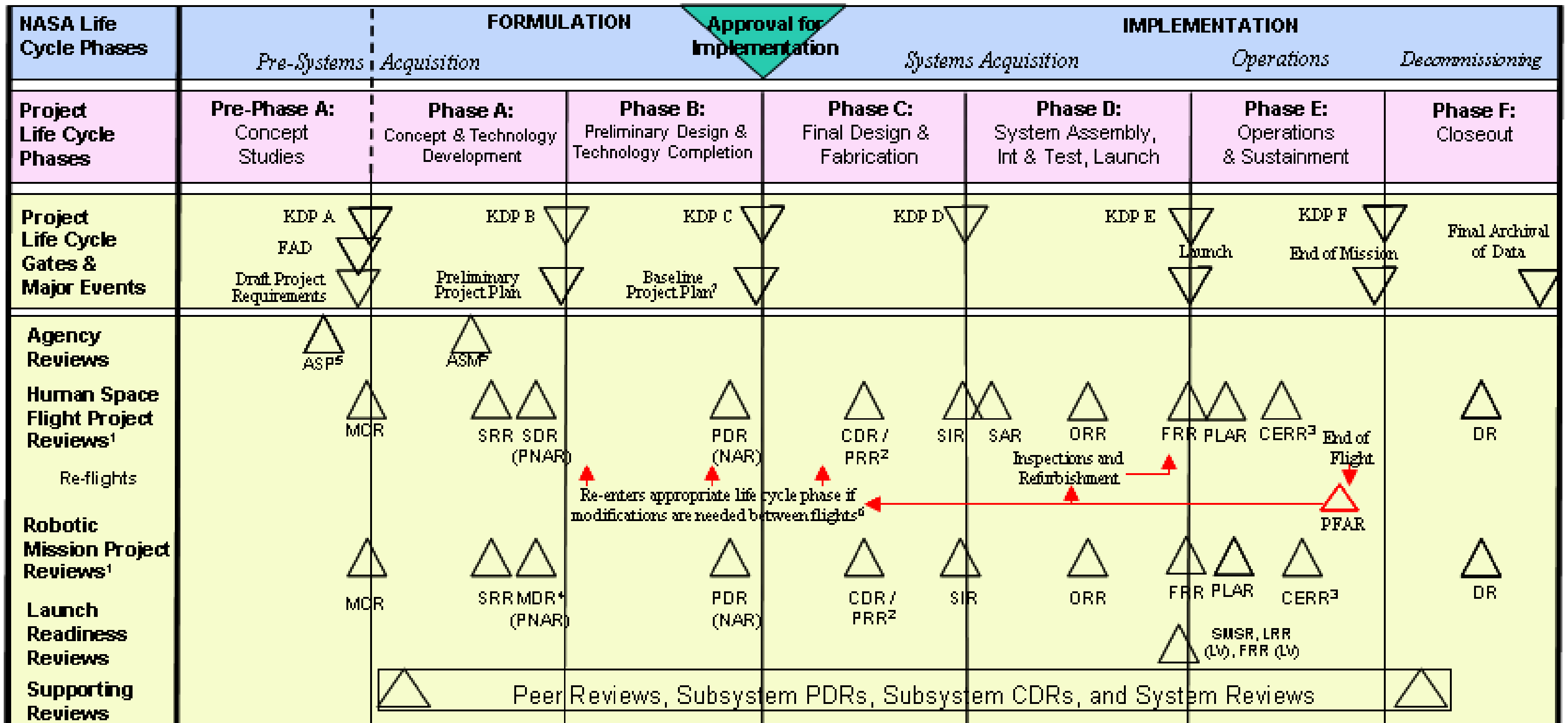
Outcomes of Project Closeout

- Completed project product or phase
- Decommissioning or disposing of the system
- Capturing lessons learned and project team knowledge
- Closeout contracts
- Retain and store project records

Phase F Products

- Phase F Project Gate Technical, Project Planning, Cost and Schedule Products
  - Final Mission Report
  - Baseline Work Agreements for next phase
  - Updated CADRe
  - Baseline System Decommissioning/Disposal Plan

NASA Project Lifecycle



FOOTNOTES

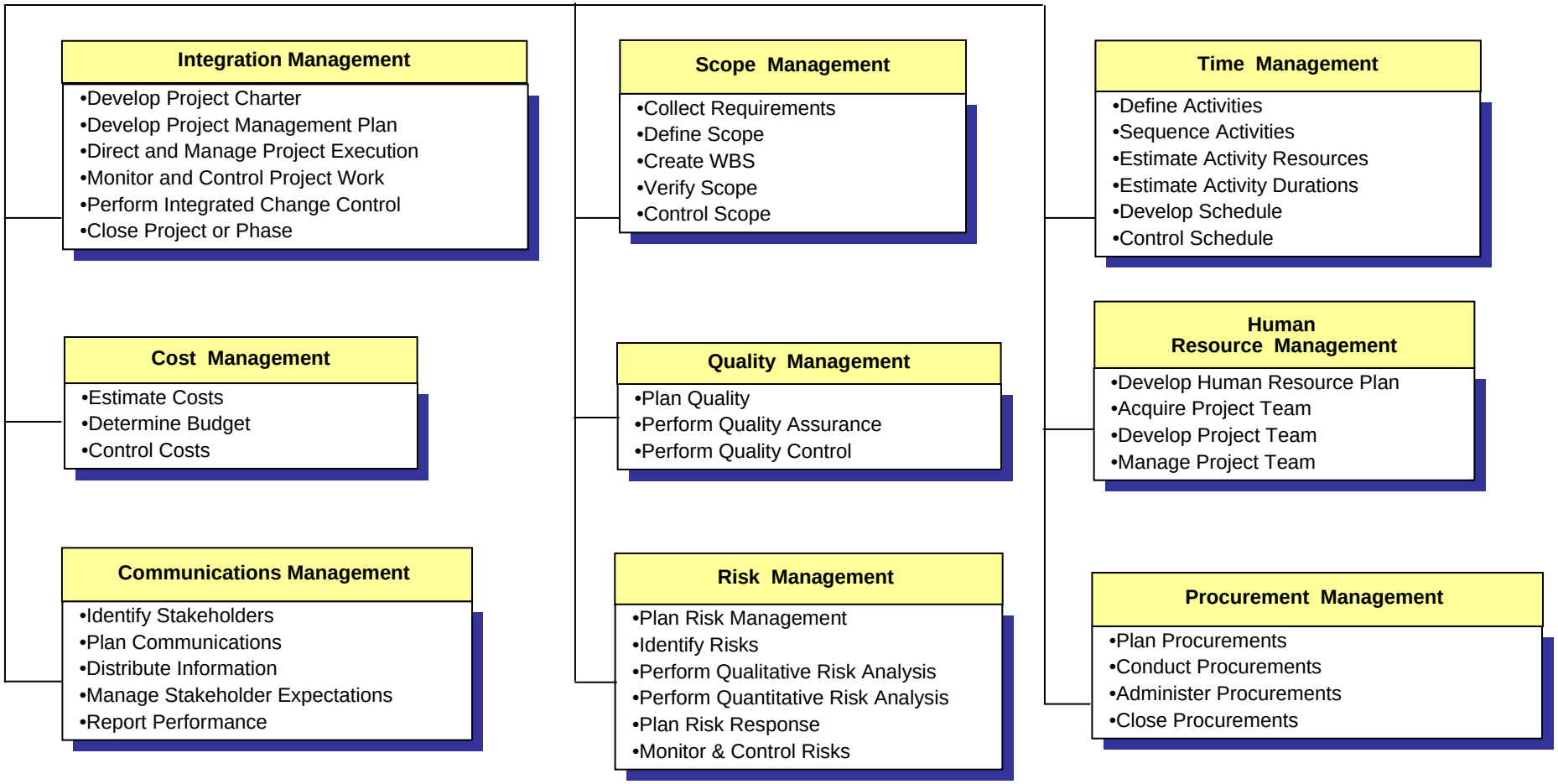
1. Flexibility is allowed in the timing, number, and content of reviews as long as the equivalent information is provided at each KDP and the approach is fully documented in the Project Plan. These reviews are conducted by the project for the independent SRB. See Section 2.5 and Table 2-6.
2. PRR needed for multiple (≥4) system copies. Timing is notional.
3. CERRs are established at the discretion of Program Offices.
4. For robotic missions, the SRR and the MDR may be combined.
5. The ASP and ASM are Agency reviews, not life-cycle reviews.
6. Includes recertification, as required.
7. Project Plans are baselined at KDP C and are reviewed and updated as required, to ensure project content, cost, and budget remain consistent.

ACRONYMS

ASP—Acquisition Strategy Planning Meeting
ASM—Acquisition Strategy Meeting
CDR—Critical Design Review
CERR—Critical Events Readiness Review
DR—Decommissioning Review
FAD—Formulation Authorization Document
FRR—Flight Readiness Review
KDP—Key Decision Point
LRR—Launch Readiness Review
MCR—Mission Concept Review
MDR—Mission Definition Review
NAR—Non-Advocate Review
ORR—Operational Readiness Review
PDR—Preliminary Design Review
PFAR—Post-Flight Assessment Review
PLAR—Post-Launch Assessment Review
PNAR—Preliminary Non-Advocate Review
PRR—Production Readiness Review
SAR—System Acceptance Review
SDR—System Definition Review
SIR—System Integration Review
SMSR—Safety and Mission Success Review
SRR—System Requirements Review

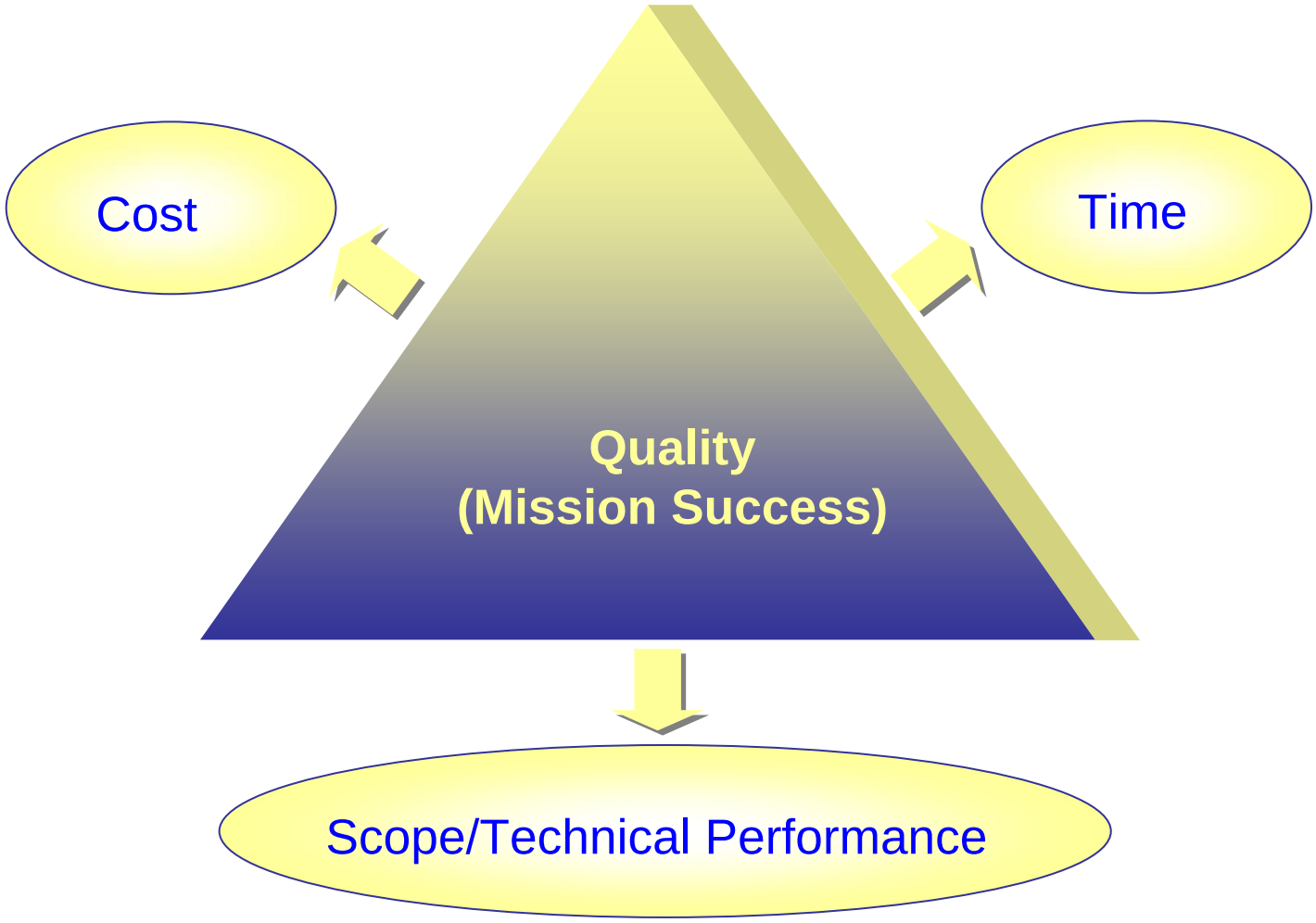
SOURCE: NPR 7120.5D

Integrated Project Management



SOURCE: A Guide to the Project Management Body of Knowledge (PMBOK® Guide) Fourth Edition

Project Triple Constraint



"Probably my best quality as a coach is that I ask a lot of challenging questions and let the person come up with the answer."

– Phil Dixon

Appendix

See PM Knowledge Web link for more supporting documents

http://pmknowledge.gsfc.nasa.gov

EVM Related Websites

All Links shown below can be found at http://pmknowledge.gsfc.nasa.gov

OMB Directives

OMB Circular A11, Part 7: Planning, Budgeting, Acquisition and Management of Capital Assets:
http://www.whitehouse.gov/omb/circulars/a11/current_year/s300.pdf
OMB Circular A 11 Part 7 Supplement - Capital Programming Guide:
http://www.whitehouse.gov/omb/circulars/a11/current_year/part7.pdf

EIA 748

ANSI-EIA 748 Guidelines:
http://webstore.ansi.org/ansidocstore/product.asp?sku=ANSI%2FEIA-748-A-1998
NDIA EIA 748 Intent Document:
http://www.ndia.org/Content/ContentGroups/Divisions1/Procurement/EVMS_IntentGuide_Nov06.pdf
NDIA Surveillance Guide:
http://www.ndia.org/Content/ContentGroups/Divisions1/Procurement/PDFs10/NDIA_PMSC_Surveillanceguide_Oct2004.pdf

NASA Directives

NPR 7120.5D Program and Project Management Requirements:
http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7120_005D_
NPR 7120.7 Institutional Requirements: not available at publication date
NPR 7120.8 Research and Technology: http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7120&s=8
NPR 7102.4C Program/Project Management:
http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=7120&s=4C
NASA FAR Supplement: http://www.hq.nasa.gov/office/procurement/regs/nfstocA.doc
NASA FAR EVM Policy: http://www.hq.nasa.gov/office/procurement/regs/pn04-19.doc
NASA Contract Performance Report Formats: http://evm.nasa.gov/reports.html

EVM Related Websites

All Links shown below can be found at http://pmknowledge.gsfc.nasa.gov

Related NASA Websites

NASA EVM Website: http://evmnasa.gov/index.html (Contains IBR Toolkit)
NASA APPEL Curriculum Website: http://appel.nasa.gov/node/28
Office of the Chief Financial Officer: http://cfo.gsfc.nasa.gov (Business Management DRD Templates)
NASA PM Challenge Website: http://pmchallenge.gsfc.nasa.gov/
NASA PM Perspectives Website: http://pmperspectives.gsfc.nasa.gov
NASA PM Knowledge Website: http://pmknowledge.gsfc.nasa.gov

DOD EVM Websites and Documents

DOD Integrated Baseline Review Guide:
www.acq.osd.mil/pm/currentpolicy/IBR_Guide_April_2003.doc
OSD EVM Website: http://www.acq.osd.mil/pm/
DOD Over Target Baseline Guide: https://acc.dau.mil/CommunityBrowser.aspx?id=19576
DOD CPR DID: http://www.acq.osd.mil/pm/currentpolicy/cpr_cfsr/CPR%20Final%203-30-05.pdf
DOD Integrated Master Plan(IMP)/Integrated Master Schedule (IMS) Preparation Guide:
www.acq.osd.mil/sse/docs/IMP_IMS_Guide_v9.pdf

Other Relevant Links

Performance Management Institute: www.pmi.org/pages/default.aspx
College of Performance Management: http://www.pmi-cpm.org/pages/home/index.html

EVM References & Related Books

- Fleming, Quentin W. (1992) *Cost/ Schedule Control Systems Criteria The Management Guide to C/SCSC (Rev. ed.)*. Chicago, IL: Probus Publishing Company.
- Fleming, Quentin W. & Koppelman, Joel M.(2005). *Earned Value Project Management* (3rd ed.). Newtown Square, PA: Project Management Institute, Inc.
- Humphreys, Gary C. (2002) *Project Management Using Earned Value*. Orange, CA: Humphreys & Associates.
- Project Management Institute. (2004) *Practice Standard for Earned Value Management*. Newtown Square, PA: Project Management Institute.
- Project Management Institute. (2008) *A Guide to the Project Management Body of Knowledge*. Newtown Square, PA: Project Management Institute.

Key EVM Terms

- **PV**- Planned Value (BCWS) ***SHOULD DO***
- **EV** – Earned Value (BCWP) ***DID DO***
- **AC** – Actual Cost (ACWP) ***WHAT IT COST***
- **BAC** – Budget at Completion (Total Work)
- **EAC** – Estimate at Completion (Total Funds)
- **ETC** – Estimate to Complete = EAC – AC
- **CV** – Cost Variance = EV-AC
- **SV** – Schedule Variance = EV-PV
- **CPI** – Cost Performance Index = EV/AC
- **SPI** – Schedule Performance Index = EV/PV
- **BCWR** - Budgeted Cost of Work Remaining = BAC - EV
- **TCPI –** To Complete Performance Index = BCWR/ETC
- **% Complete** = EV/BAC
- **% Spent** = AC/EAC (or AC/BAC)
- **% Complete Planned** = PV/BAC

EVM Terminology

- ***ACTUAL COST (AC):*** total costs actually incurred and recorded in accomplishing work performed during a given time period for a schedule activity or WBS component. Also referred to as actual cost of work performed (ACWP).
- ***ACTUAL COST OF WORK PERFORMED (ACWP):*** see actual cost (AC).
- ***BASELINE:*** the approved time phased plan, plus or minus approved project scope, cost, schedule, and technical changes. Includes cost, schedule and performance measurement baselines.
- ***BUDGET AT COMPLETION (BAC):*** the sum of all the budget values established for the work to be performed on a project or activity. The total planned value for the project.
- ***BUDGETED COST OF WORK PERFORMED (BCWP):*** see earned value (EV)
- ***BUDGETED COST OF WORK SCHEDULED (BCWS):*** see planned value (PV)
- ***CONTROL ACCOUNT (CA):*** a management control point where the integration of scope, budget, actual cost, and schedule takes place, and where the measurement of performance will occur.
- ***CONTROL ACCOUNT PLAN (CAP):*** a plan for all the work and effort to be performed in a control account. Each CAP has a definitive statement of work, schedule, and time-phased budget. Can be broken down into lower level work packages.
- ***COST PERFORMANCE INDEX (CPI):*** a measure of cost efficiency on a project. It is the ratio of earned value (EV) to actual costs (AC). CPI=EV divided by AC.
- ***COST VARIANCE (CV):*** in EVM, the difference between the EV and the AC. CV=EV minus AC.
- ***CRITICAL PATH:*** the series of activities that determines the duration of the project. It is the longest sequential path through the project, and path with the least amount of total slack/float.

SOURCE: "A Guide to the Project Management Body of Knowledge" (PMBOK)

EVM Terminology

- ***EARNED VALUE (EV):*** the physical work accomplished, plus the authorized budget for this work. Also referred to as budgeted cost of work performed (BCWP).
- ***ESTIMATE AT COMPLETION (EAC):*** the expected total cost of an activity and/or project when the defined scope of work will be completed.
- ***ESTIMATE TO COMPLETION (ETC):*** the expected cost needed to complete all the remaining work for an activity and/or the project.
- ***HORIZONTAL INTEGRATION/TRACEABILITY:*** condition where authorized work is scheduled in a manner that describes its sequence and identifies task interdependencies
- ***INTEGRATED MASTER SCHEDULE:*** expands the project plan to the work planning level by defining all project activities, durations, interdependencies and milestones. It consists of both the baseline and current forecast schedules which provide the framework for time phasing and coordinating all project effort.
- ***ORGANIZATIONAL BREAKDOWN STRUCTURE (OBS):*** a hierarchically organized depiction of the project organization arranged so as to relate the work packages to the performing organizational units.
- ***PERFORMANCE MEASUREMENT BASELINE (PMB):*** approved time phased plan for the project work against which project execution is compared and deviations are measured for management control.
- ***PLANNED VALUE (PV):*** the authorized budget assigned to the scheduled work to be accomplished for an activity/project. Also referred to as budgeted cost of work scheduled (BCWS).
- ***RESPONSIBILITY ASSIGNMENT MATRIX (RAM):*** a structure that relates the project organization breakdown structure to the work breakdown structure to help ensure that each component of the project's scope of work is assigned to a responsible person.

SOURCE: "A Guide to the Project Management Body of Knowledge" (PMBOK)

EVM Terminology

- ***SCHEDULE PERFORMANCE INDEX (SPI):*** a measure of schedule efficiency on a project. It is the ratio of earned value (EV) to planned value (PV). SPI=EV divided by PV.
- ***SCHEDULE VARIANCE (SV):*** in EVM, the difference between the EV and the PV. SV=EV minus PV.
- ***TOTAL SLACK:*** the amount of duration an activity can be delayed from its "early finish" date without impacting the project's completion date; can be positive, zero or negative
- ***VERTICAL INTEGRATION/TRACEBILITY***: consistency in dates, status and revisions throughout all levels of the schedule; CAMs know when tasks must begin and end
- ***WORK PACKAGE:*** a deliverable or project work component at the lowest level of each branch of the work breakdown structure.

SOURCE: "A Guide to the Project Management Body of Knowledge" (PMBOK)

Additional Schedule Terms

- **Integrated Master Schedule (IMS) -** a logic networked-based framework of the activities and milestones intended for successful project execution.
- **Milestone -** An event, or point in time, which identifies significant, measurable progress.
- **Activity -** A discrete element of work that needs to be performed.
- **Constraint -** A restriction or limitation on project activities, logic, resources usage, etc. within the IMS.
- **Duration -** Number of periods or working time needed to perform the effort. (Can be dependent upon amount of resources applied or available).
- **Free Slack -** The amount of time an activity can be delayed before it impacts the early start of the succeeding activity.
- **Total Slack -** The amount of time an activity can be delayed from its early finish date without delaying the planned completion or end date of the project. Can be positive, zero, or negative.

Additional Schedule Terms

- **Project Slack -** Amount of time between the project's early completion date and it's target or contract end date.
- **Critical Path -** The longest sequential path through a logic network, from beginning to end, that defines the earliest a project can finish.
  - Path with the longest overall duration
  - Path with the least amount of total slack
- **Schedule Reserve -** A pre-planned amount of activity duration incorporated into the project schedule. Used as a protective cushion, or buffer, for absorbing the time impact of risks or problems with in-scope work. Reserve is represented as a "dummy activity" in the logic network.
- **Baseline -** A record, benchmark, target, or snapshot of the schedule at a given point in time. The original schedule plan plus approved changes.

EIA – 748 Guidelines

(1) Organization

(a) Define the authorized work elements for the program. A Work Breakdown Structure (WBS), tailored for effective internal management control, is commonly used in this process.

(b) Identify the program organizational structure, including the major subcontractors responsible for accomplishing the authorized work, and define the organizational elements in which work will be planned and controlled.

(c) Provide for the integration of the company's planning, scheduling, budgeting, work authorization, and cost accumulation processes, and as appropriate, the program WBS and the program organizational structure.

(d) Identify the company organization or function responsible for controlling overhead (indirect costs).

(e) Provide for integration of the program WBS and the program organizational structure in a manner that permits cost and schedule performance measurement by elements of either or both structures as needed.

SOURCE: EIA 748

(2) Planning and Budgeting

(a) Schedule the authorized work in a manner which describes the sequence of work and identifies significant task interdependencies required to meet the requirements of the program.

(b) Identify physical products, milestones, technical performance goals, or other indicators that will be used to measure progress.

(c) Establish and maintain a time-phased budget baseline, at the control account level, against which program performance can be measured. Budget for far-term efforts may be held in higher level accounts until an appropriate time for allocation at the control account level. Initial budgets established for performance measurement will be based on either internal management goals or the external customer-negotiated target cost including estimates for authorized but undefinitized work. On Government contracts, if an over-target baseline is used for performance measurement reporting purposes, prior approval must be obtained from the Government contracting officer.

(d) Establish budgets for authorized work with identification of significant cost elements (e.g., labor, material) as needed for internal management and for control of subcontractors.

(2) Planning and Budgeting, continued

(e) To the extent it is practical to identify the authorized work in discrete work packages, establish budgets in terms of dollars, hours, or other measurable units. Where the entire control account is not subdivided into work packages, identify the far-term effort in larger planning packages for budget and scheduling purposes.

(f) Provide that the sum of all work package budgets plus planning package budgets within a control account equals the control account budget.

(g) Identify and control level-of-effort activity by time-phased budgets established for this purpose. Only that effort which is unmeasurable or for which measurement is impractical may be classified as level of effort.

(h) Establish overhead budgets for each significant organizational component of the company for expenses which will become indirect costs. Reflect in the program budgets, at the appropriate level, the amounts in overhead pools that are planned to be allocated to the program as indirect costs.

(i) Identify management reserves and undistributed budget.

(j) Provide that the program target cost goal is reconciled with the sum of all internal program budgets and management reserves.

(3) Accounting

(a) Record direct costs in a manner consistent with the budgets in a formal system controlled by the general books of account.

(b) When a WBS is used, summarize direct costs from control accounts into the WBS without allocation of a single control account to two or more WBS elements.

(c) Summarize direct costs from the control accounts into the contractor's organizational elements without allocation of a single control account to two or more organizational elements.

(d) Record all indirect costs that will be allocated to the contract.

(e) Identify unit costs, equivalent units costs, or lot costs when needed.

(3) Accounting, continued

(f) For Earned Value Management Systems (EVMS), the material accounting system will provide for the following:

i. Accurate cost accumulation and assignment of costs to control accounts in a manner consistent with the budgets using recognized, acceptable, costing techniques.

ii. Cost performance measurement at the point in time most suitable for the category of material involved, but no earlier than the time of progress payments or actual receipt of material.

iii. Full accountability of all material purchased for the program, including the residual inventory.

(4) Analysis and Management Reports

(a) At least on a monthly basis, generate the following information at the control account and other levels as necessary for management control using actual cost data from, or reconcilable with, the accounting system:

i. Comparison of the amount of planned budget and the amount of budget earned for work accomplished. This comparison provides the schedule variance.

ii. Comparison of the amount of the budget earned and the actual (applied where appropriate) direct costs for the same work. This comparison provides the cost variance.

(b) Identify, at least monthly, the significant differences between both planned and actual schedule performance and planned and actual cost performance and provide the reasons for the variances in the detail needed by program management.

(c) Identify budgeted and applied (or actual) indirect costs at the level and frequency needed by management for effective control, along with the reasons for any significant variances.

(4) Analysis and Management Reports, continued

(d) Summarize the data elements and associated variances through the program organization and/or WBS to support management needs and any customer reporting specified in the contract.

(e) Document managerial actions taken as the result of earned value information.

(f) Develop revised estimates of cost at completion based on performance to date, commitment values for material, and estimates of future conditions. Compare this information with the performance measurement baseline to identify variances at completion that are important to company management and any applicable customer reporting requirements including statements of funding requirements.

(5) Revisions and Data Maintenance

(a) Incorporate authorized changes in a timely manner, recording the effects of such changes in budgets and schedules. In the directed effort prior to negotiation of a change, base such revisions on the amount estimated and budgeted to the program organizations.

(b) Reconcile current budgets to prior budgets in terms of changes to the authorized work and internal replanning in the detail needed by management for effective control.

(c) Control retroactive changes to records pertaining to work performed that would change previously reported amounts for actual costs, earned value, or budgets. Adjustments should be made only for correction of errors, routine accounting adjustments, effects of customer or management directed changes, or to improve the baseline integrity and accuracy of performance measurement data.

(d) Prevent revisions to the program budget except for authorized changes.

(e) Document changes to the performance measurement baseline.

NASA FAR SUPPLEMENT
Earned Value Management

NASA FAR Supplement

- **EXISTING FAR DEFINITIONS**
- "**Development,**" as used in this part, means the systematic use of scientific and technical knowledge in the design, development, testing, or evaluation of a potential new product or service (or of an improvement in an existing product or service) to meet specific performance requirements or objectives. It includes the functions of design engineering, prototyping, and engineering testing; it excludes subcontracted technical effort that is for the sole purpose of developing an additional source for an existing product.
- "**Applied research**" means the effort that (a) normally follows basic research, but may not be severable from the related basic research; (b) attempts to determine and exploit the potential of scientific discoveries or improvements in technology, materials, processes, methods, devices, or techniques; and (c) attempts to advance the state of the art. When being used by contractors in cost principle applications, this term does not include efforts whose principal aim is the design, development, or testing of specific items or services to be considered for sale; these efforts are within the definition of "development," given below.

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NASA FAR Supplement

- **EXISTING FAR INSTRUCTION**
- **(NASA FAR Supplement must be read with existing FAR language to understand in full)**
- **Subpart 34.2—Earned Value Management System**
- **34.201 Policy.**
- (a) An Earned Value Management System (EVMS) is required for major acquisitions for development, in accordance with OMB Circular A-11. The Government may also require an EVMS for other acquisitions, in accordance with agency procedures.
- (b) If the offeror proposes to use a system that has not been determined to be in compliance with the American National Standards Institute /Electronics Industries Alliance (ANSI/EIA) Standard-748, Earned Value Management Systems, the offeror shall submit a comprehensive plan for compliance with these EVMS standards. Offerors shall not be eliminated from consideration for contract award because they do not have an EVMS that complies with these standards.
- (c) As a minimum, contracting officers shall require contractors to submit EVMS monthly reports for those contracts for which an EVMS applies.
- (d) EVMS requirements will be applied to subcontractors using the same rules as applied to the prime contractor.
- (e) When an offeror is required to provide an EVMS plan as part of its proposal, the contracting officer will determine the adequacy of the proposed EVMS plan prior to contract award.

NASA FAR Supplement

- **34.202 Integrated Baseline Reviews.**
- (a) When an EVMS is required, the Government will conduct an Integrated Baseline Review (IBR).
- (b) The purpose of the IBR is to verify the technical content and the realism of the related performance budgets, resources, and schedules. It should provide a mutual understanding of the inherent risks in offerors'/ contractors' performance plans and the underlying management control systems, and it should formulate a plan to handle these risks.
- (c) The IBR is a joint assessment by the offeror or contractor, and the Government, of the—
- (1) Ability of the project's technical plan to achieve the objectives of the scope of work;
- (2) Adequacy of the time allocated for performing the defined tasks to successfully achieve the project schedule objectives;
- (3) Ability of the Performance Measurement Baseline (PMB) to successfully execute the project and attain cost objectives, recognizing the relationship between budget resources, funding, schedule, and scope of work;
- (4) Availability of personnel, facilities, and equipment when required, to perform the defined tasks needed to execute the program successfully; and
- (5) The degree to which the management process provides effective and integrated technical/schedule/cost planning and baseline control.
- (d) The timing and conduct of the IBR shall be in accordance with agency procedures. If a pre-award IBR will be conducted, the solicitation must include the procedures for conducting the IBR and address whether offerors will be reimbursed for the associated costs. If permitted, reimbursement of offerors' pre-award IBR costs is governed by the provisions of FAR Part 31.

NASA FAR Supplement

- **34.203 Solicitation provisions and contract clause.**
- (a) The contracting officer shall insert a provision that is substantially the same as the provision at FAR 52.234-2, Notice of Earned Value Management System-Pre-Award IBR, in solicitations for contracts that require the contractor to use an Earned Value Management System (EVMS) and for which the Government requires an Integrated Baseline Review (IBR) prior to award.
- (b) The contracting officer shall insert a provision that is substantially the same as the provision at 52.234-3, Notice of Earned Value Management System-Post Award IBR, in solicitations for contracts that require the contractor to use an Earned Value Management System (EVMS) and for which the Government requires an Integrated Baseline Review (IBR) after contract award.
- (c) The contracting officer shall insert a clause that is substantially the same as the clause at FAR 52.234-4, Earned Value Management System, in solicitations and contracts that require a contractor to use an EVMS.

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NASA FAR Supplement

- **EXISTING NASA FAR SUPPLEMENT INSTRUCTION**
- **Subpart 1834.0 -- General**
- **1834.003 Responsibilities.**

  (a) NASA's implementation of OMB Circular No. A-109, Major Systems Acquisition, and **FAR Part 34** is contained in this Part and in NASA Policy Directive **(NPD) 7120.4** , "Program/Project Management," and NASA Procedures and Guidelines **(NPR) 7120.5** , "NASA Program and Project Management Processes and Requirements".
- **Subpart 1834.2--Earned Value Management System**
- **1834.201 Policy.**
- (a) Application of an Earned Value Management System (EVMS) is required for all acquisitions for development designated as major in accordance with OMB Circular A-11, and for development or production contracts and subcontracts, including those for flight and ground support requirements, and institutional requirements (facility, IT investment, etc.) as follows:
- (i) For contracts and subcontracts valued at $20M or more, and contracts and subcontracts for major acquisitions valued at less than $20M, the EVMS shall comply with the guidelines in the ANSI/EIA-748 Standard.
- (ii) For contracts and subcontracts valued at $50M or more, the contractor shall have an EVMS that has been formally validated and accepted by the Government.
- (iii) For contracts and subcontracts for other than major acquisitions valued at less than $20M, earned value management application is optional and is a risk-based decision that is at the discretion of the program/project manager.
- (iv) EVM is not required on contracts for non-developmental engineering support services, steady state operations, basic and applied research, and routine services such as janitorial services or grounds maintenance services. In these cases, application of EVM is at the discretion of the program/project manager.
- (e) Contracting officers shall request the assistance of the cognizant Defense Contract Management Agency (DCMA) office in determining the adequacy of proposed EVMS plans.

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- **1834.202 Integrated baseline reviews**.
- (d) Use of pre-award IBRs is limited to the second or subsequent phases of a phased acquisition (see 1817.73). When a pre-award IBR is contemplated, the contracting officer shall include the instructions with respect to the schedule and conduct of the IBR in the proposal request.
- **1834.203 Solicitation provisions and contract clause.**
- The FAR EVMS solicitation provisions and contract clause are not used in NASA contracts. See 1834.203-70 for the NASA EVMS solicitation provision and contract clause.
- **1834.203-70 NASA solicitation provision and contract clause.**
  Except for the contracts identified in 1834.201(a)(iv), the contracting officer shall insert –
- (a) The provision at 1852.234-1, Notice of Earned Value Management System, in solicitations for contracts for --
- (1) Development or production, including flight and ground support projects, and institutional projects (facility, IT investment, etc.), with a value exceeding $20M; and
- (2) Acquisitions of any value designated as major by the project manager in accordance with OMB Circular A-11; and
- (b) The clause at 1852.234-2, Earned Value Management System, in solicitations and contracts with a value exceeding $50M that include the provision at 1852.234-1. The contracting officer shall use the clause with its Alternate I when the contract value is less than $50M .

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- **EXISTING NASA FAR SUPPLEMENT EVM PROVISIONS AND CLAUSES**
- **1852.234-1 Notice of Earned Value Management System.**
- As prescribed in 1834.203-70(a), insert the following provision:
- **NOTICE OF EARNED VALUE MANAGEMENT SYSTEM (NOVEMBER 2006)**
- (a) The offeror shall provide documentation that its proposed Earned Value Management System (EVMS) complies with the EVMS guidelines in the American National Standards Institute (ANSI)/Electronic Industries Alliance (EIA)-748 Standard, Earned Value Management Systems.
- (b) If the offeror proposes to use a system that currently does not meet the requirements of paragraph (a) of this provision, the offeror shall submit its comprehensive plan for compliance with the EVMS guidelines to the Government for approval.
- (1) The plan shall—
- (i) Describe the EVMS the offeror intends to use in performance of the contract;
- (ii) Distinguish between the offeror's existing management system and modifications proposed to meet the EVMS guidelines in ANSI/EIA-748;
- (iii) Describe the management system and its application in terms of the EVMS guidelines;
- (iv) Describe the proposed procedure for application of the EVMS requirements to subcontractors;

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- (v) Describe how the offeror will ensure EVMS compliance for each subcontractor subject to the flowdown requirement in paragraph (c) whose EVMS has not been recognized by the Cognizant Federal Agency as compliant according to paragraph (a);
- (vi) Provide documentation describing the process and results, including Government participation, of any third-party or self-evaluation of the system's compliance with the EVMS guidelines; and
- (vii) If the value of the offeror's proposal, including options, is $50 million or more, provide a schedule of events leading up to formal validation and Government acceptance of the Contractor's EVMS. This schedule should include progress assistance visits, the first visit occurring no later than 30 days after contract award, and a compliance review as soon as practicable. The Department of Defense Earned Value Management Implementation Guide (https://acc.dau.mil/CommunityBrowser.aspx?id=19557) outlines the requirements for conducting a progress assistance visit and validation compliance review.
- (2) The offeror shall provide information and assistance as required by the Contracting Officer to support review of the plan.
- (3) The Government will review the offeror's EVMS implementation plan prior to contract award.
- (c) The offeror shall identify in its offer the major subcontractors, or major subcontracted effort if major subcontractors have not been selected, planned for application of the EVMS requirement. Prior to contract award, the offeror and NASA shall agree on the subcontractors, or subcontracted effort, subject to the EVMS requirement.
- (d) The offeror shall incorporate its compliance evaluation factors for subcontractors into the plan required by paragraph (b) of this provision.
- **(End of provision)**

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- **1852.234- 2 Earned Value Management System.**
- As prescribed in 1834.203-70(b) insert the following clause:
- **EARNED VALUE MANAGEMENT SYSTEM**
- **(NOVEMBER 2006)**
- (a) In the performance of this contract, the Contractor shall use--
- (1) An Earned Value Management System (EVMS) that has been determined by the Cognizant Federal Agency to be compliant with the EVMS guidelines specified in the American National Standards Institute (ANSI)/Electronic Industries Alliance (EIA) – 748 Standard, Industry Guidelines for Earned Value Management Systems (current version at the time of award) to manage this contract; and
- (2) Earned Value Management procedures that provide for generation of timely, accurate, reliable, and traceable information for the Contract Performance Report (CPR) required by the contract.
- (b) If, at the time of award, the Contractor's EVMS has not been determined by the Cognizant Federal Agency to be compliant with the EVMS guidelines, or the Contractor does not have an existing cost/schedule control system that is compliant with the guidelines in the ANSI/EIA-748 Standard (current version at the time of award), the Contractor shall apply the system to the contract and shall take timely action to implement its plan to obtain compliance/validation. The Contractor shall follow and implement the approved compliance/validation plan in a timely fashion. The Government will conduct a Compliance Review to assess the contactor's compliance with its plan, and if the Contractor does not follow the approved implementation schedule or correct all resulting system deficiencies identified as a result of the compliance review within a reasonable time, the Contracting Officer may take remedial action, that may include, but is not limited to, a reduction in fee.

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- (c) The Government will conduct Integrated Baseline Reviews (IBRs). Such reviews shall be scheduled and conducted as early as practicable, and if a pre-award IBR has not been conducted, a post-award IBR should be conducted within 180 calendar days after contract award, or the exercise of significant contract options, or within 60 calendar days after distribution of a supplemental agreement that implements a significant funding realignment or effects a significant change in contractual requirements (e.g., incorporation of major modifications). The objective of IBRs is for the Government and the Contractor to jointly assess the Contractor's baseline to be used for performance measurement to ensure complete coverage of the statement of work, logical scheduling of the work activities, adequate resourcing, and identification of inherent risks.
- (d) Unless a waiver is granted by the Cognizant Federal Agency, Contractor proposed EVMS changes require approval of the Cognizant Federal Agency prior to implementation. The Cognizant Federal Agency shall advise the Contractor of the acceptability of such changes within 30 calendar days after receipt of the notice of proposed changes from the Contractor. If the advance approval requirements are waived by the Cognizant Federal Agency, the Contractor shall disclose EVMS changes to the Cognizant Federal Agency at least 14 calendar days prior to the effective date of implementation.

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- (e) The Contractor agrees to provide access to all pertinent records and data requested by the Contracting Officer or a duly authorized representative. Access is to permit Government surveillance to ensure that the Contractor's EVMS complies, and continues to comply, with the EVMS guidelines referenced in paragraph (a) of this clause, and to demonstrate—
- (1) Proper implementation of the procedures generating the cost and schedule information being used to satisfy the contract data requirements;
- (2) Continuing application of the accepted company procedures in satisfying the CPR required by the contract through recurring program/project and contract surveillance; and
- (3) Implementation of any corrective actions identified during the surveillance process.
- (f) The Contractor shall be responsible for ensuring that its subcontractors, identified below, comply with the EVMS requirements of this clause as follows:
- (1) For subcontracts with an estimated dollar value of $50M or more, the following subcontractors shall comply with the requirements of this clause.
- (Contracting Officer to insert names of subcontractors or subcontracted effort).
- (2) For subcontracts with an estimated dollar value of less than $50M, the following subcontractors shall comply with the requirements of this clause except for the requirement in paragraph (b), if applicable, to obtain compliance/validation.
- (Contracting Officer to insert names of subcontractors or subcontracted effort.)

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- (g) If the contractor identifies a need to deviate from the agreed baseline by working against an Over Target Baseline (OTB) or Over Target Schedule (OTS), the contractor shall submit to the Contracting Officer a request for approval to begin implementation of an OTB or OTS. This request shall include a top-level projection of cost and/or schedule growth, whether or not performance variances will be retained, and a schedule of implementation for the reprogramming adjustment. The Government will approve or deny the request within 30 calendar days after receipt of the request. Failure of the Government to respond within this 30-day period constitutes approval of the request. Approval of the deviation request does not constitute a change, or the basis for a change, to the negotiated cost or price of this contract, or the estimated cost of any undefinitized contract actions .
- **(End of clause)**
- **(ALTERNATE I)**
- **(NOVEMBER 2006)**
- As prescribed in 1834.203-70(b), substitute the following paragraph (b) for paragraph (b) of the basic clause:
- (b) If, at the time of award, the Contractor's EVMS has not been determined by the Cognizant Federal Agency to be compliant with the EVMS guidelines, or the Contractor does not have an existing cost/schedule control system that is compliant with the guidelines in the ANSI/EIA-748 Standard (current version at the time of ward), the Contractor shall apply the system to the contract and shall take timely action to implement its plan to be compliant with the guidelines. The Government will not formally validate/accept the Contractor's EVMS with respect to this contract. The use of the Contractor's EVMS for this contract does not imply Government acceptance of the Contractor's EVMS for application to future contracts. The Government will monitor compliance through routine surveillance.

NPD 1000.5 Confidence Levels

NPD1000.5: Confidence Levels

- h. Base programs and projects involved in space flight and information technology per NPR 7120.5, NASA Space Flight Program and Project Management Requirements, and NPR 7120.7, NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements on the following:
- (1) For implementation of each major program segment (e.g., Constellation- - full ISS capability, lunar exploration, etc.), programs and projects are to be baselined or rebaselined and budgeted based on a joint cost and schedule probabilistic analysis developed by the program or project in accordance with the following:
- (a) Programs are to be baselined or rebaselined and budgeted at a confidence level of 70 percent or the level approved by the decision authority of the responsible Agency-level management council. For a 70 percent confidence level, this is the point on the joint cost and schedule probability distribution where there is a 70 percent probability that the project will be completed at or lower than the estimated amount and at or before the projected schedule. The basis for a confidence level less than 70 percent is to be formally documented.

NPD1000.5: Confidence Levels

- (b) Projects are to be baselined or rebaselined and budgeted at a confidence level consistent with the program's confidence level.
- (2) As a minimum, projects are to be funded at a level that is equivalent to a confidence level of 50 percent or as approved by the decision authority of the responsible management council.(3) Joint cost and schedule confidence levels are to be developed and maintained for the life cycle cost and schedule associated with the initial lifecycle baselines (e.g., for space flight programs and projects baselines established at KDP-1 or KDP-C).
- (a) The initial life cycle baselines may include development of an initial operational capability, initial operations, and sustaining engineering consistent with the definition of the content of the life cycle, along with the traditional development effort.
- (b) The cost estimating methodology used for operational phases may be different than those used for other portions of the lifecycle. The operations phase methodology will be reviewed and utilized as a component of the integrated program/project lifecycle confidence level calculations.

NPD1000.5: Confidence Levels

- (4) Programs and projects that are in extended operational phases are generally not required to develop or maintain confidence level estimates. The adequacies of budget requests for extended operational phases are to be demonstrated and evaluated through the annual budget cycle processes. The Agency policy on joint cost and schedule confidence level estimating applies to significant developments related to new or upgraded capabilities included in extended operations.
- (5) The program's or project's proposed cost and schedule baseline are to be assessed by an independent review team. The program or project is to present and justify its resulting cost and schedule to the decision authority of the responsible Agency-level management council. The independent review team is to discuss with the decision authority its key concerns with the plans and baselines proposed by the program or project.
- (6) Commitments made to organizations outside NASA are to be based on the budgeted cost and schedule associated with the confidence level approved by the decision authority of the responsible Agency-level management council.
- (7) Programs and projects are to be annually reviewed by the responsible Mission Directorate or Mission Support Office to confirm to the decision authority of the responsible Agency-level management council that their current baseline life-cycle cost estimates and funding strategy and the annual NASA budget submissions are consistent. Significant changes to funding strategy are to be reviewed with and approved by the decision authority of the responsible Agency-level management council.

Quick Reference Acronym List

- AC – Actual Cost
- ACWP – Actual Cost of Work Performed
- ANSI – American National Standards Institute
- AOA – Analysis of Alternatives
- BAC – Budget at Completion
- BCWP – Budgeted Cost of Work Performed
- BCWR – Budgeted cost for work remaining
- BCWS – Budgeted Cost of Work Scheduled
- CA – Control Account
- CADRe – Cost Analysis Data Requirement
- CAP – Control Account Plan
- CAMs – Control Account Managers
- CCA – Circuit Card Assembly
- CCB – Change Control Board
- CDR – Critical Design Review
- CPAF – Cost plus award fee
- CPI – Cost Performance Index
- CPR – Cost Performance Report
- CV – Cost Variance
- CWBS – Contractor Work Breakdown Structure
- DOD – Department of Defense
- EAC – Estimate at Completion
- EIA – Electronic Industries Alliance
- ETC – Estimate to Completion
- ESA – European Space Agency
- ESMD – Exploration Systems Mission Directorate
- EV – Earned Value
- EVM – Earned Value Measurement
- EVMS – Earned Value Management Systems
- FAD – Formulation Authorization Document
- FASAV – Federal Acquisition Streamlining Act of 1994 Title V
- FP – Fixed Price
- GAO – Government Accountability Office
- GFE – Government Furnished Equipment
- GFY – Government Fiscal Year
- GPRA – Government Performance and Results Act
- IBR – Integrated Baseline Review
- IEAC – Independent Estimate at Completion

Quick Reference Acronym List (cont'd)

- IMS – Integrated Master Schedule
- IOC - Initial Operational Capability
- I&T – Integration & Test
- ISRU – In-situ Resource Utilization
- ITMRA – Information Technology Management Reform Act of 1996
- KDP-C – Key Decision Point C
- LEO – Launch & Early Orbit
- LOA – Letters of Agreement
- LRE – Latest Revised Estimate
- Jintt – Lunar Oxygen
- MDAA – Mission Directorate Associate Administrator
- MOA – Memorandum of Agreement
- MOU – Memorandum of Understanding
- MSR – Monthly Status Review
- NAR – Non-advocate review
- NPR – NASA Procedural Requirements
- OBS – Organizational Breakdown Structure
- OCE – Office of the Chief Engineer
- ODC – Other Direct Cost
- OMB – Office of Management & Budget
- PCA – Program Commitment Agreement
- PDR - Preliminary Design Review
- PIU – Power Interface Unit
- PMB – Performance Measurement Baseline
- PMC – Program Management Council
- PMO – Project Management Office
- PPBE – Planning Programming Budgeting and Execution
- PV – Planned Value
- PWB – Printed Wiring Board
- QA – Quality Assurance
- RAM – Responsibility Assignment Matrix
- S&MA – Safety & Mission Assurance
- SOW – Statements of Work
- SPI – Schedule Performance Index
- SV – Schedule Variance
- TBD – To be Determined
- TCPI – To Complete Performance Index
- UFE – Unallocated Future Expenses
- VAC - Variance at Completion
- WBS – Work Breakdown Structure
- WFF – Wallops Flight Facility